TRANSACTIONS

OF THE ILLUMINATING ENGINEERING SOCIETY

"......the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto"

Featuring

Address of President

By Ward Harrison

1923 Convention Papers

VOL. XVIII. OCTOBER, 1923 NO. 8

TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

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TRANSACTIONS
OF THE
ILLUMINATING ENGINEERING SOCIETY

VOL. XVIII — OCTOBER, 1923 — No. 8

Service

THE Accomplishments of the Illuminating Engineering Society, since its inception seventeen years ago, have been noteworthy in its direction of advancing the knowledge of the science and art of Illuminating Engineering. That its endeavors in this field have been recognized is evidenced by its growth and continuous success. It should not, however, rest upon these achievements alone, but these activities should be accompanied by an earnest effort to be also of material value in creating agencies through which the information and data acquired may be sent broadcast to the thousands of interested individuals in the lighting industry spread out over the country.

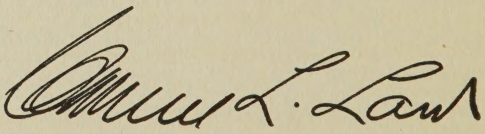
The Constitution of the Society provides a means by which this may be accomplished. In fact, it offers two ways: First—the society publication, TRANSACTIONS, an excellent means of spreading the knowledge, which is a reference and permanent record of our activities; Second—and of extreme importance, through the medium of meetings of the Sections and Chapters. Not enough stress can be laid upon the latter method. As these meetings increase in importance, attendance and popularity, the service to the industry increases in like proportion. Yet there is not a sufficient number of these Sections and Chapters, as they should be established in all of our larger cities, and it is for this

purpose solely that great emphasis is now being placed upon this activity. The importance of this issue must not be underestimated for the proper functioning of the Society as a whole depends principally upon its Sections and Chapters and through their success only can our organization establish a very definite standing in the lighting industry and increase our opportunities to be of actual service to all branches.

It is primarily our function to disseminate useful information that will aid in bringing about improved lighting conditions. This can more readily be accomplished by a closer cooperation of the various Sections, Chapters and Local Representatives throughout the country. The progress made by us has a material bearing upon the atmosphere of a community, and it is our great responsibility, therefore, to see that all channels through which our information may be disseminated are taken advantage of. And, by close communion of these agencies we can more readily accomplish our object of rendering a real service to the industry. Progression, not retrogression should be our constant aim, which might be reduced to a formula:—

$$(\mathrm{S}+\mathrm{C})^{n} = (\textsc{s}+\textsc{a}+\textsc{r}) \Bumpeq \text{TRUE SERVICE}$$

transcribed meaning, *Sections, plus Chapters, to the nth power, should yield Suggestions, plus Action, plus Results, which again reduced, yields TRUE SERVICE.*



Foreword on Proposed Activities of Committees

BY CLARENCE L. LAW

AT the suggestion of the Committee on Editing and Publication a communication was sent to each Committee Chairman, asking for a brief statement on the proposed activities of their Committees for the coming administrative year.

The response to this request was very gratifying and the reports that follow will give some idea of the proposed work which the Committees will undertake.

The functions of the Board of Examiners and the Finance Committee are outlined in the Constitution and therefore, no statement from these Chairmen has been made.

It is hoped that all Committee Chairmen will feel free to attend any or all of the Council Meetings, held each month during the year, so that they may have the opportunity of reporting personally on the progress of their Committee as well as to form some idea as to how the Council functions.

Council Meetings are held the second Thursday of each month, at the headquarters of the Society, unless otherwise arranged. Committee Chairmen, when attending these Council Meetings, should be prepared to report briefly, as the time at the disposal of the members is limited.

Committee on Papers

The Committee on Papers is planning to render as much service as possible to Sections and Chapters. As a step in this direction we are now at work compiling a list of available sources of speakers and papers.

Several of the manufacturers, laboratories and other organizations have men who frequently travel about the country. Many of these men are recognized leaders in the development of the art of illumination. It is believed that in general they would be glad to address sections or chapters as opportunities arise.

The Committee on Papers will send each Section, Chapter and Local Representative a list of men who are willing to volunteer for

this activity, the subjects on which they are best qualified to talk, and will further endeavor to develop some scheme whereby the official representative is kept informed of travelling itineraries, etc.

To expedite publication of the TRANSACTIONS it is planned to more closely coordinate the work of the general committee with the sectional committees. When papers of interest to the Society as a whole are presented before sections they should appear in the TRANSACTIONS. It has been somewhat difficult in the past for the office to obtain copies for consideration. This is a matter calling for closer cooperation on the part of Section Chairmen.

It is hoped to make the program at the annual convention as far as possible of direct practical value to the rank and file of the membership. It is believed that a few papers of the highest grade are preferable to a long program treating many subjects. To this end the Committee will welcome suggestions as to topics that are believed to be timely and of the greatest value to the greatest number. With these suggestions in hand your Committee will endeavor to obtain a paper from the best authority on that particular phase of the art.

It seems desirable to have more discussions of papers than has sometimes prevailed. It is in discussion that the various sides of a given question are brought forth. For this to take place it is necessary that the papers be available for study by the members in advance of the convention. The attempt will therefore be made to carry out this and a special effort to secure discussion from those qualified.

The Committee bespeaks your interest, cooperation and frank expression of opinion on its work.

ALVIN L. POWELL, *Chairman*

Committee on Editing and Publication

The TRANSACTIONS of the Society are perhaps the biggest single effort which is undertaken by the Society. The direct expense of printing and publication is about one third of the Society's expenses and if the General Office expenses for labor, printing and postage in this connection is allocated to the proper cause, the expense of the Society for the Transactions will probably be found to be about half of its income.

Realizing this and that the TRANSACTIONS are the medium for reaching all of the membership (it is probable that less than one half of the membership is affiliated closely with the sectional or chapter activities) it is the Committee's hope that the TRANSACTIONS may be made, even more than in the past, a medium for the dissemination of news of the industry in addition to its function as the archives of the Society's deliberations.

The attempt will be made this year in cooperation with the Committee on Papers to issue the TRANSACTIONS on a definite schedule. The membership in general can help this program in two ways.

First, by sending to the General Office when occasion permits, notes on items of interest to lighting men, clippings from other papers for our Reflections section and news of the various unusual installations which are being completed from time to time, or notes about men of the industry;

Second, by correcting and returning promptly manuscripts for discussion. A copy of the TRANSACTIONS is in a sense like a picture puzzle, almost useless unless all the parts are available and in their proper positions.

The Committee bespeaks your active cooperation in these two particulars and promises that as this is effected, it will be reflected in a corresponding improvement in the numbers of the TRANSACTIONS which come to you.

NORMAN D. MACDONALD, *Chairman*

Committee on Lighting Legislation.

During the year 1923-24 the Committee will be occupied largely with a campaign to bring the revised Code of Lighting School Buildings to the attention of legislative bodies, school boards, architects, and others interested in enactments, rules, and regulations in regard to school buildings.

It is planned to issue a simplified version of this Code, much abbreviated, for the use of those who find the present Code too technical.

The campaign of education to be conducted in connection with the introduction of the School Lighting Code and the adoption of this Code by the states will be much the same as the campaign that was conducted in the case of the Factory Lighting Code. The work on

both of these Codes will be carried on along similar lines under the following headings:

(a) Preparation of a guide to inspectors and cooperation with states, municipalities and others in interpreting the rules, regulations and provisions of the Codes.

(b) Lectures by representatives of the Committee, to school authorities and factory representatives.

(c) Service on international, national, state and municipal committees.

(d) Representation at public hearings on the Codes.

(e) Circularization to legislative bodies in those states that have not put the Codes into effect.

The Committee plans to continue the campaign to further the general recognition of the importance of light as a factor in accident prevention, and in particular to bring about the inclusion of the item of lighting as a prominent clause in all industrial accident insurance policies.

LOUIS B. MARKS, *Chairman.*

Committee on Membership

The splendid work of the Committee on Membership aided by the members in general resulted in the election of 289 new members during the past year,—an increase of 58.5 per cent over the members elected during the preceding year.

The aim of the Society, namely, "The dissemination of knowledge relating to the theory and practice of Illuminating Engineering" can best be accomplished by an ever-increasing membership in the Society.

A knowledge of the principles of Illuminating Engineering brings about the realization of the great benefit it engenders to mankind and the creative force it is to more and better business.

The Committee on Membership has signified its willingness to serve again in that capacity, and the Society may rest assured that they will do everything in their power to surpass the splendid record just made. It seems only fair to expect that the members in general will do their part and the procuring of one new member by each member of the Society would mean the doubling of its membership and would evidence on their part a serious interest in the Society's welfare.

The Chairman sincerely hopes for this cooperation, and will be very glad to give any information or aid to any member having a prospective member in view. He further desires to express his appreciation to all those who aided in the past year's activities.

G. Bertram Regar, *Chairman.*

Committee on Motor Vehicle Lighting.

The Committee on Motor Vehicle Lighting feeling that the matter of Specifications for Laboratory Tests of Headlighting Appliances has reached a stage where for the time being no further revisions are called for, proposes during the coming year to devote itself chiefly to a consideration of methods whereby the character of headlighting which is contemplated in the testing specifications may be generally attained on the road. The Committee recognizes that the use of approved equipment on headlights does not in any way insure proper road illumination and the absence of glare. It believes that while in proportion to the number of cars, lighting conditions on the road have been greatly improved, yet they are still far from being satisfactory, and wishes to bend its efforts chiefly toward assisting to the best of its ability in improving these road conditions. A number of propositions are before it for consideration with respect to education of the public and to a more thorough and intelligent enforcement of the laws. Just what success the Committee will have in these endeavors is of course problematical.

While turning its chief endeavors in the above direction, the Committee does not intend to fail to give attention to any points in which its previous work can be improved, and will welcome suggestions toward this end as well as toward the perhaps broader problem of improved road conditions.

Clayton H. Sharp, *Chairman.*

Committee on Nomenclature and Standards

The principal duty of the Committee on Nomenclature and Standards during the year will be to complete the revision of the booklet on Illuminating Engineering Nomenclature and Photometric Standards so that the revised edition can be adopted as American standard practice. It will then be presented for con-

sideration at the 1924 meeting of the International Commission on Illumination in the hope that further progress may be made in securing international agreement on names and definitions.

The Society has had success in combining the efforts of men whose activities lie along widely divergent lines, such as professional practice, technical and scientific research, manufacture, sales, and engineering of the most practical sort. Successful cooperation of such groups is to some extent dependent upon a common technical language which facilitates the interchange of ideas. The work of this committee is directed primarily toward the development of such a common language so that we may all understand each other.

Proposed changes in the former standards have been set forth in the Committee's Reports for 1922 and 1923, and the Committee would like to have comments or suggestions from all classes of members before final action is taken on the changes.

Some Sections and Chapters have found it worth while to have talks on the elementary principles of illumination, including methods of design, calculation, and measurement. Discussion of these subjects is likely to bring out points in which the standard nomenclature appears to be lacking in clearness or precision, and if so the Committee will be glad to hear about them. If the definitions are not clear or the terms not usable, now is the time to improve them. Positive and constructive proposals are of course most helpful, but criticism of weak points will be welcome, and the Committee will do its best to remedy deficiencies which may be pointed out.

E. C. CRITTENDEN, *Chairman.*

Committee on Progress

It is the intention of the Committee to continue the practice of previous years in preparing periodically for inclusion in the TRANSACTIONS of the Society an Illumination Index, covering allarticles on the subject to be found in periodicals available to the Committee.

The usual procedure will be followed in preparing the annual report of the Committee, which at the last Convention was known as the "Year's Progress in Illumination", the material for which is obtained from articles published in the technical and scientific press and from engineers in charge of street lighting of various large cities.

It is the intention to include in next year's report among the references under the appropriate headings the various subjects which have appeared in the Transactions or have been presented before the Society. It is hoped in this way to make the report a still more complete record of activities in illuminating engineering.

FRANCIS E. CADY, *Chairman*

Committee on Research

The recent Convention Report of this Committee looks forward as well as backward, and there is nothing which I could say by way of program of work for the coming year that would be different from the work outlined in that Report.

ERNEST F. NICHOLS, *Chairman*

Committee to Cooperate with Fixture Manufacturers

In 1922 a tentative Code of Luminaire Design was prepared by this Committee and published. It was submitted to many fixture manufacturers, designers, illuminating engineers, etc. Very little criticism has been received but from these a few minor changes are in contemplation.

It is the aim to add two more sections to this Code, one dealing with artistic fixtures, which embody proper lighting principles for various purposes, and the other, a section on the influence of installation on fixture design.

The Chairman and Secretary of this Committee have work under way in regard to the first of the proposed sections. When the work is done on both sections, it is the plan to incorporate it into the Code of Luminaire Design and to publish this complete for final distribution.

During past years members of this Committee have been individually active in spreading the gospel of proper fixtures and proper lighting principles among fixture designers, fixture manufacturers, fixture dealers, and glassware manufacturers. The Committee members collectively and individually have attended meetings of these various organizations including the Illuminating Glassware Guild. They have given lectures and have aided in various demonstrations.

It is the plan to continue such activity. The Committee has been an effective means of contact with fixture manufacturers and the Illuminating Glassware Guild as well as others. The work that it is trying to do is very important but there are many difficulties in the way. Fortunately, these difficulties are becoming less formidable each year.

M. LUCKIESH, *Chairman*

Committee on Sky Brightness

The program for the year 1923-24 contemplates the inauguration of qualitative measurements of daylight, perhaps with the Rotatory Dispersion Colorimetric Photometer designed by Mr. I. G. Priest of the Committee.

The Committee also hopes to avail itself of daylight intensity records that the U. S. Public Health Service expects to obtain from photo-electric cells it has purchased for installation in Washington. These should give more detailed information respecting the extreme variations of daylight intensity with weather conditions than can be obtained from eye readings of a photometer.

There is also a probability that measurements of sky brightness may be made during balloon and airplane flights, and correlated with determinations of the dust content of the atmosphere.

Data are available for extending the charts published in the May 1923 number of the TRANSACTIONS, giving the intensity of daylight on horizontal and on vertical surfaces in the United States east of the Mississippi River at Latitude 42° North, under both clear and cloudy sky conditions, to other latitudes and regions in the United States. This will not be undertaken, however, unless the demand seems to justify the considerable labor involved.

The Committee would be glad to receive suggestions as to ways in which it may serve the interests of members of the Society.

H. H. KIMBALL, *Chairman*

REFLECTIONS

Stimulating Plants and Animals

EXPERIMENTS at Columbia University show that plant growth proceeds successfully under electric light. Flowers and vegetables subjected to several hours of artificial illumination outgrew those of the same planting which received only daylight.

Many professional poultry raisers use electric light night and morning to increase the egg production of their hens. The New Jersey experiment station at New Brunswick reported last month that hens stimulated by artificial light which kept them awake after sundown and caused their morning to begin before sunrise in winter laid at least ten eggs more a season that their sisters whose quarters lacked modern improvements. Most poultrymen who use artificial light in their henhouses think that the margin is larger and that keeping their hens awake pays good profits.

Scientists may see in this proof of the stimulating power of light, but the practical poultryman has a simpler explanation. Chickens have hearty appetites and are everlastingly scratching around for food. They go to sleep early in winter simply because they cannot hunt food in the dark. In the morning they are more hungry than sleepy, and the first crack of dawn finds them ready for breakfast. Hence, say the practical poultrymen who disregard science, hens that put in a long day at work in winter are better nourished and consequently lay more eggs that those working from sun to sun on short days.

In primitive days man slept from sun to sun because darkness kept him from doing anything else. Now eight hours is the standard sleeping night as well as the standard working day. But such an eminent scientist as Edison thinks that sleep is a good deal of a habit and greatly overdone.

Perhaps a common explanation of all these diverse phenomena may be found in the philosopher's saying that labor is the price of life. The tree labors in growth, the fowl labors in search of food,

the scientist in search of facts. Each advance of knowledge narrows the gulf that separates the animal from the vegetable. The bean vine follows the sun round the bean pole as inevitably as the moth follows the candle round a room. Similarly light seems to stimulate the physical and chemical processes of the tree or plant. Plants, like man, work better in light than in darkness. Their roots reach out for more nourishment, their cells function more rapidly. Sleep, as the physiologists long ago noted, is a slowing down process. Artificial light keeps these Columbia plants awake and working.

But labor is not the whole of life. These experiments on light and growth will not be completed until attempts have been made to perpetuate the species through specimens that have been subjected to artificial light. Florists may get splendid specimens by this method; but the plants may be weakened in vitality in spite of their size and showiness.

With regard to human beings it has been suggested that physical recuperation is the least of sleep's benefits. Some psychologists hold that undue loss of sleep tends to bring on mental and nervous ailments, because the subconscious mind, which works while we sleep, has lacked time enough to sort, check up, erase or accept the impressions and rationalizations stored up by day. It is entirely possible that in plants, beasts and human beings alike too little sleep may seriously weaken the individual in ways not at once apparent. Whether it does so in the case of plants no doubt will soon be determined.—*Editorial, New York Herald, Oct. 29, 1923.*

PAPERS

ADDRESS OF THE PRESIDENT*

By Ward Harrison

For the subject of this address I would refer you to a much quoted passage from the Constitution of the Society, a clause which is reprinted on the face of every issue of our Transactions; namely, "That the object of this Society shall be the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto". Even in the year of the Society's formation it was recognized that there were two distinct tasks before it; first, the reaching out after new facts and new principles in illuminating engineering; and second, the dissemination of these and older truths to the industry and to the public.

At the present time, in fact, at least once *every* year, it seems fitting that we should ask ourselves two questions: first, what at present is our greatest need, *technically*, in the practice of our profession; and second, wherein lies our greatest opportunity for the dissemination of illuminating engineering information to the public. No doubt, if a poll were taken there would be almost as many answers to these questions as there are members of the Society, but taking advantage of the opportunity which has been afforded me I will attempt to state what my own answers would be.

PART I

In my opinion our greatest technical need today is for a better working knowledge of *brightness* and *glare*, from both a quantitative and a qualitative standpoint. As the result of the general adoption during the past ten years of such expressions as "foot-candle", "lumen", and "coefficient of utilization", it is safe to say that there are now several thousand persons in the United States who have a very definite conception of the relation existing between the flux generated by a light source and the resultant foot-

*An Address presented before the Annual Convention of the Illuminating Engineering Society, Lake George, N. Y., September 24-28, 1923.

candles of illumination in a room. In other words, we think in lumens fairly well. But, how many are there who can say the same thing when the subject is that of brightness, the progeny of lumens and the factor with which finally we are all most vitally concerned; concerned with it on the working plane because there it is the thing which enables us to see; concerned with it in the case of the light sources for there it is the thing which in excess may readily defeat vision and even impair eyesight.

How little thought is really given to questions of brightness by practicing engineers is well exemplified by the general prescription of "about twice as much light for work on dark textiles as for work on light fabrics", whereas actual brightness measurements would indicate that 10 or 15 to 1 as nearer the proper ratio. Again, how many of us, if asked to criticize a lighting specification for any given interior can feel certain as to whether the luminaires are going to prove comfortable or glaring, unless, of course, we have had experience with an almost exactly similar installation before. Right at the present time we seem further than ever from any simple mathematical formula by which such questions can be answered.

It is fortunate that all of our more precise instruments for measuring illumination may be calibrated to read brightness as well, and this circumstance should be of substantial assistance in increasing our store of "installation data" on the subject. At the same time it would also prove very helpful if an instrument comparable in simplicity and cost to the foot-candle meter, or possibly a modification of this instrument itself, were developed with which brightness could be read directly with accuracy sufficient for practical purposes.

Strange as it may seem, glare is a subject to which but little attention has been given by those of our members who are primarily interested in scientific research. For example, there is at present apparently no data available from this group to answer even such a simple question as the following:—Which is the preferable of two light sources, (a) which has a uniform brightness throughout, and (b) which has a low brightness at the periphery, increasing to a higher value near the center, assuming that the candlepower of the units and their *average* brightness is the same in both cases?

Now your President lays no claim to originality in offering the suggestion that questions of brightness are entitled to greater consideration than is usually accorded them. This subject has been brought up for discussion on numerous occasions by members of this Society but unfortunately we have always stopped there; we have made little or no progress. We are prone to look at the whole subject as exceedingly complex, particularly so in contrast with the more usual calculations involving lumens and foot-candles. May it not be that in the face of a really serious effort this difficulty would prove to be only a fancied one arising simply from ignorance on our part?

One of the greatest helps in the solution of any problem is an exchange of thought between individuals and an exchange of thought presupposes a language—a nomenclature. I believe that our progress in the present matter is considerably impeded by the lack of a simple term in which to express brightness, one which will apply equally well to luminaires and to surfaces illuminated, and finally, one which will be quite readily comprehended by the man on the street; one encounters real difficulty in trying to explain millilambert to him.

It is generally accepted that whenever new fundamental units are established involving distance, weight or time, the C. G. S. System should be followed, and with this in view our Committee on Nomenclature and Standards supplied us some years ago with our fundamental definitions. Of these the lumen and the candle might be termed truly international units, for in their practical application at least, they involve neither a unit of length nor of weight; the C. G. S. unit of brightness then established was the lambert and likewise the lux, or meter-candle, was defined as our fundamental unit of illumination intensity. In practice, however, most Americans think in feet and inches and the only generally used unit of illumination intensity in this country today is the "Foot-Candle". What we need also for general use in this country is a unit of brightness based upon our accepted unit of intensity, the "Candle", and our common unit of length, the "Foot". A logical unit would be the brightness of a spherical source of one foot radius having a uniform intensity of 1 candle in all directions; or if you prefer, the brightness of a perfectly translucent sphere of one foot radius surrounding a source of 1 candle. Such a unit

renders the computation of brightness values for many units a comparatively easy matter. For example, a spherical diffusing globe 8″ in diameter having an output of 80 per cent would, when equipped with a lamp of 150 spherical candlepower, have a mean brightness of 1080 units computed as follows:

$$\frac{150 \times 24^2 \times 0.8}{8^2} = 1080$$

This unit would also have the very practical advantage that it would represent the mean brightness of a surface of 100 per cent reflection factor when illuminated to an intensity of one foot-candle; that is, one lumen per square foot.

There is still one thing more to be said in favor of a unit of brightness of the dimensions stated above; namely, that it is of about the right size for practical use. With it the brightness of working surfaces, at least in interior lighting, will usually be found in the range of from 0.1 to 10, numbers that are easy to comprehend and when we speak of the brightness of light sources we will usually find ourselves up in the hundreds or thousands, figures which are far more certain to cause the layman to pause and consider, than would the same brightness expressed as a decimal fraction.

In the opinion of the writer there is much in the choice of the size of a unit, there is also much in the choice of the name. In the term "foot-candle" the precedent has been established of prefixing our non-metric units involving length with the term "foot" which at once shows to what system it belongs. The same plan followed in the case of the unit of brightness would forever eliminate any possibility of it being confused with lambert. If the term "foot" could be coupled, not with some abstract term, but rather with a short Anglo-Saxon word which conveyed to the listener some inkling of the meaning of the whole word, the resulting combination should prove most desirable. An expression which seems to come very near to fulfilling these requirements is "foot-bright", and it is my wish to submit this term for the consideration of the Committee on Nomenclature and Standards.

In weighing the relative advantages and disadvantages of this and other terms the fact must not be lost sight of that we are an Illuminating Engineering Society, not a Society of Illuminating Engineers; that to be of value our findings must be capable of

dissemination; that success in influencing the design of any considerable proportion of the lighting installations in this country depends upon making our technique seem extremely simple, not upon making it complex. My strongest recommendation for "foot-bright" is that it sounds almost common-place.

PART II

The second division of this address has reference to our obligation and our opportunity for the dissemination of knowledge of the theory and practice of illuminating engineering and how we may best go about this task. Since our last convention the number of chapters of this Society has increased from three to seven; in other words, the number of cities in which local branches are established is now eleven. Do not these facts suggest an answer to our problem? Is it not true that the most effective work that can be undertaken by the present local branches and by additional ones as they are organized, is to concentrate upon the dissemination of lighting information?

Plans for monthly meetings and for lectures should be arranged with a view to interesting successively engineers, architects, fixture manufacturers, and similar groups. The co-operation of city and suburban school authorities we should seek perhaps, most of all, for through them can be secured, not only lighting in the schools which will cease to be a menace to the eyesight of our own and our neighbors' children, but also instruction in the principles of lighting, which will better fit those of the next generation to know good lighting for themselves. It may be recalled I spoke briefly on this phase of the subject at the last convention. This week we have for your consideration the draft of a chapter on lighting which has been prepared at the request of the Council as a suggestion to writers of text books on High School physics and also as a guide to instructors on this subject. The monograph will be open for discussion at the Friday meeting, and the thoughtful criticism of the membership of this Society is sincerely requested. When this pamphlet is printed in final form, it will become the very fitting task of our sections and chapters to secure its general adoption in their individual territories.

One may say that there is nothing new in these proposals for section and chapter activity; that some of our branches have for years arranged joint meetings and programs which would interest

those outside of their own membership. This is true, but for the Society as a whole, the effort has not been organized. One section has not had the benefit of the experience of others, and never has a complete program for the year's work been outlined for them by this Society. Likewise, they have never been asked to show the tangible results of a year's effort along such lines. To those who are fortunate enough to be able to attend our annual conventions these four-day periods represent perhaps the high point of the Society's achievement; in any event, it is a most enjoyable one. But we must not lose sight of the fact that the real strength of this Society lies in its sections and chapters, and that is why I believe that our greatest potentiality for progress lies in the plans which will be developed in the Section and Chapter Conference which is scheduled for Friday morning next. On behalf of the Council I bespeak your attendance at this Conference and your support.

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REPORT OF COMMITTEE ON PRESIDENTIAL ADDRESS

Your Committee on Presidential Address feels that President Harrison has rounded out a very successful administration with an address which constitutes a valuable contribution to the art. He points out the necessity of further elucidation of the subject of brightness and glare. With reference to brightness, he indicates the need for the adoption of some simple and comprehensible unit and terminology and makes a definite suggestion to this end.

Your Committee is in hearty sympathy with the President's view and without assuming to pass on the merit of his specific suggestions recommends that the Society's Committee, within whose scope this question lies, give early and serious consideration to the problem to which the President has so pertinently directed our attention.

P. S. Millar
G. H. Stickney
L. B. Marks, Chairman

The report was unanimously accepted by the convention.

HOW CAN THE I. E. S. BE MADE MORE TRULY A NATIONAL BODY*

BY D. McFARLAN MOORE**

About 74 per cent of the membership of the Illuminating Engineering Society resides east of Chicago. There are nine States that have no members at all and twenty-seven States that have less than one dozen members and yet there are in the United States millions of people interested in, or associated in a business way with light. Various membership committees have carefully studied methods which would seem to follow the path of least resistance towards the goal of a very great increase in the total membership and also have it well distributed. However, the gain altho steady, has not been rapid. The deterrents to joining our Society are of many varieties but finance is always important. Council has approved of the formation of Chapters on such liberal terms that it seems to the Committee on New Sections and Chapters that the formation of New Chapters should be of much value to the National Society. It permits of our interesting an unlimited number of people in the objects of the Society, yet at a nominal expense to them. Meetings of Chapters not only develop interest in the minds of many who will later become full members of the National Society but also greatly stimulate the enthusiasm of those who are already members.

A number of New Chapters have recently been formed and seem to be well worth while and it is hoped that more assistance will be given towards the formation of such Chapters so that it can be said that each State in the union has at least one Chapter of the Illuminating Engineering Society. To assist those who are inclined to be helpful in this important matter the following information will prove of great assistance—

*A Paper presented before the Annual Convention of the Illuminating Engineering Society, Lake George, N. Y., September 24-28, 1923.

**Chairman, Committee on New Sections and Chapters, I. E. S.

If there are a large number of industries in a specific vicinity, that are either directly or indirectly interested in illuminating engineering, the formation of a local Chapter will be more easily accomplished, and also more good will result from its formation. The most essential requirement and the one most difficult of fulfillment is that ten regular members of the Illuminating Engineering Society, (they can be either full members or associate members) must file a petition approximately as follows—

> "We the undersigned herewith petition the Council of the Illuminating Engineering Society to authorize the formation of a local Chapter of the Society in——————
> to cover the vicinity of——————————."

And send it to the Chairman of the Committee on New Sections and Chapters who in turn will endeavor to obtain the formal approval of Council and then inform the petitioners that all is ready for the organization meeting. The General Office in New York is requested to make a list of all the names of the members of the Society living in the vicinity where it is proposed to form a New Chapter. If less than ten are thus obtainable an effort should be made to interest a sufficient number of new members so that the petition will be in proper form for presentation to Council. Those interested in obtaining new members are reminded that the annual dues for full members are $15.00 and for associate members $7.50 and that an initiation fee of $2.50 is required for either full members or associate members. A proposed constitution for a new Chapter is also immediately forwarded to those interested but a statement is made that the Chapter dues can be of any amount those locally interested desire; one dollar for example. Therefore, members of such a Chapter only, can claim association with the Illuminating Engineering Society, yet as indicated pay only a very small amount per year. However, they will not receive copies of the Society TRANSACTIONS or be eligible to its offices, etc. Such members of a Chapter often later become full members of the National organization. Our Society has now approved of seven Chapters as follows: Toronto, Cleveland, San Francisco Bay Cities, Columbus, Northern New Jersey, Michigan and Los Angeles and their increase during the last year together with the lively character of their meetings indicate that a definite effort should be made

to very greatly increase this line of activity as already indicated. The unoccupied fields are so enormous that it is fitting to say that a start has only been made. Many of the definite localities where there seems to be no good reason why a Chapter should not be formed should be selected and an earnest effort made in every instance to promptly bring a Chapter into being and thereby not only greatly benefit our National Organization but also fulfill the primary object of our organization, viz., to further the interests of better lighting.

SECTION DEVELOPMENT CONFERENCE*

CHAIRMAN CLARENCE L. LAW: As you know, the object of the meeting this morning is to have an informal discussion on Section and Chapter development. We want to see what we can do to aid Sections, Chapters and Local Representatives throughout the country, in order to promote the work of the Society.

If there are any Section or Chapter Chairmen or Secretaries here will they please stand up and announce their names and Sections, so that we may all know each other?

The following Section and Chapter officers and Local Representatives were present:

W. V. Batson, Chairman, New England Section.

Julius Daniels, Secretary, New England Section.

W. S. Fitch, Board of Managers, New England Section.

L. J. Lewinson, Chairman-elect, New York Section.

S. K. Barrett, Chairman Papers Committee, New York Section.

C. L. Dows, Chairman, Cleveland Chapter.

J. M. Ketch, Chairman, Michigan Chapter.

W. H. Woods, Toronto Chapter.

George C. Cousins, Toronto Chapter.

Ellsworth Francisco, Northern New Jersey Chapter.

Charles Gallo, Northern New Jersey Chapter.

E. C. Crittenden, Local Representative, Washington, D. C.

F. L. Loomis, Pittsburgh, Pa.

J. D. Lee, Trenton, N. J.

CHAIRMAN LAW: We have not set a program this morning and I thought we could make the discussions very informal, therefore, I have not any definite plan with regard to this meeting. I would like to call on President Harrison to open the Conference.

PRESIDENT HARRISON: It seems to me that if we were to analyze this Society; thinking of it as divided into component parts, and were to try to rate the various parts, we would probably

*Held at Lake George, N. Y., during the Annual Convention of the Illuminating Engineering Society, September 28, 1923.

first think of our Conventions and on a scale of one hundred,—rate them very high. The enthusiasm is good, the attendance is good, papers are good, and we accomplish, I believe, a very considerable amount; that is judging from the opinions of many people with whom I talk.

Next we would probably consider the plan of operation; the Constitution, the arrangement of executive authority, etc., as well thought out. In other words, the business of the Society runs smoothly, and we would, therefore, give the plan of operation a high rating.

Likewise, I think you would give a high rating to the work of the General Committees; Committees like those on Lighting Legislation, Motor Vehicle Lighting, Nomenclature and Standards, and the other general committees.

In the minds of the majority of the members all of these things would probably be found to rate higher than most of the Section Activities. In fact, that is why the suggestion was made that this conference be called to exchange ideas among the Section Officers. What one has found to be successful in his locality the others can try with the result that it should be easier to plan a successful year's program. I hope some steps will be taken along that line today. Perhaps we can make an outline of an entire series of meetings to offer to a Section, or Chapter, and they can accept as much of it as they wish.

Another point that I believe we ought all to get our minds together on is that if we want this Society to grow, and to cover a wider territory, we must put it on a broader basis—and such basis, it seems to me, is the Section and the Chapter. It has been gratifying, indeed, to see the way new Chapters have sprung up during the past year. Now that we have these Chapters we should give them something very definite to do.

CHAIRMAN LAW: Thank you Mr. Harrison. Mr. Moore is Chairman of our Committee on New Sections and Chapters. Will you give us about five minutes on your work of last year, Mr. Moore?

D. MCFARLAN MOORE: I don't know whether talking about the work of last year will be the thing of most interest. Our new President who has made a success of his administration already seems to be impressed with the importance of the development of

Chapters, largely, then trusts that the Sections will follow the Chapters.

For several years, I was Chairman of the Membership Committee, and it must be now three or four years ago that I began to realize, as Chairman of the Membership Committee, the utter lack of geographic area that was covered by the Society as it then existed.

The members of the Council know that I started in three or four years ago sort of ripping things up the back, as regards the claim that we were a National Society, when it isn't far from the truth to say we are about one-quarter of what we ought to be, and what I want to do is to see us rise to the point of four-quarters. That is, we only represent about a quarter of the country in a way that indicates that it is perfectly reasonable for us to be four times larger and do four times as much good. That is what I want to get at. Let us avoid this thing of traveling upward perhaps under false colors, or something of that kind.

When we investigated the ways in which this could be done, it looked as though the chief resistance was in the line of Chapters and because of my making some remarks of that kind, the job was thrown on me and we went ahead and organized some new Chapters.

The problem can be stated very specifically. Any man here from a managerial standpoint would say, if he was laying out a new business, "why that is an easy thing to do. All you need to do is just pick out the portions of the country where there ought to be a Chapter, where there are so many thousands of people who are interested in lighting, and yet don't know that the Illuminating Engineering Society exists." It's a fact, I think, as I pointed out the other day, there are a few states that haven't got a member—and there are 36 states that have less than a dozen members.

Now let us go out and pick out these areas and plant seed of the very best variety, not taking men merely because the general managers of big corporations say to a dozen men "Here, join this Society". That is mushroom growth. We don't want that. We want men who are deeply interested in the subject of lighting and will stick. Such men will gradually drift into our conventions, and there are many men here who are just going away from this

convention inspired with a new feeling, and they will hereafter work for the good of the cause.

Mr. Moore presented his paper at this point. See page 729.

DISCUSSION

SECRETARY S. G. HIBBEN: Mr. President, it might be well to have a thorough understanding of the foundation of this discussion, because some of us are not acquainted with the Section and Chapter divisions.

You saw the map with the colored lamps indicating the positions of these Sections, Chapters and Local Representatives, and in order that you may refresh your minds on the subject I will read some statistics. Of the four Sections we have a membership as follows:

New York	430
Philadelphia	216
Chicago	164
New England Section	143

In the Chapters formed this past year and including the others previously existing—in other words, in the seven Chapters we now have—we have a Cleveland membership of 74; Northern New Jersey, 103; Columbus, 25; Los Angeles, 20; Michigan, which is the Detroit Chapter, 34; San Francisco, 40; Toronto, 31. That is the registered membership, but does not represent the persons reached by the chapters.

It is rather interesting to notice the Northern New Jersey Chapter with a membership of 103, and the Chicago and New England Sections with memberships of around about 150. It is quite possible some of these Chapters may outstrip the Sections so far as actual numbers of members are concerned.

CHAIRMAN LAW: I think we may as well throw this open for further discussion. Before I do this, I want to offer what I think is a splendid suggestion; it was made by Mr. Millar. He suggested that if any of you have pictures or snapshots that you have taken of members of your different Sections around at this Convention, that you send them into Headquarters. Then we will ask the Committee on Editing and Publication whether they won't consider devoting a page or two in the TRANSACTIONS to these pictures. So if any of you have any such pictures, please send them into Mr.

Hibben, at Headquarters, and I am sure the Chairman of the Committee on Editing and Publication will do his best to get them in.

This meeting is now thrown open for general discussion. I should like to hear particularly from some Chapter Chairmen as to the experiences they have had with the development of their Chapters and how it is going along.

G. G. Cousins: Mr. Chairman, relative to Mr. Hibben's remarks on the membership of the Chapters, there is a condition that exists in our Toronto Chapter that possibly exists in some others. I believe Mr. Hibben's tabulation refers to Society members in the Chapters.

Secretary Hibben: Yes, not to others that are strictly Chapter members.

G. G. Cousins: That is the point I wish to ask about. We have a number of Chapter members whom we classify as "affiliates" and we are going to recruit our membership from those.

We are entering now on the third year of our Toronto Chapter, and we have learned a lot since we started. In discussing our field for the development of the Chapters, we ought to get a lot of men who are very intimately connected with illumination and know practically nothing about illuminating equipment or lighting principles. Those men are very largely in the fixture business, and contractors. There are a number of contractors who are progressive and study lighting principles.

Our plan was to make the meetings such that those men could get some of the fundamental principles so that they could talk more intelligently when they were speaking of the various materials that they are dealing in. We found that apparently they didn't want to know. It was very hard to get them interested.

We had a very good year, our first year, I think. The second year was practically as good but we found it harder work to keep up interest. Now we have come to the point where we have been talking over means of getting out along more definite lines and there are two schools of thought amongst those who are very much concerned in it. It has been argued on one hand that if we charged five dollars a year for Chapter membership, our present rate is three dollars exclusive of Society fees, those who paid the money would feel they had to get something out of it and would come. On the other hand, there are several of us who think that a number

who might be interested to the extent of paying two or three dollars, would simply balk at five dollars a year. With the type of subjects we have been handling, we have found it rather difficult to gauge the type of meeting and the papers presented. A good many think of "Engineering Society" as some highbrow stuff and balk at it from the start.

We want to go ahead. We don't want to stand still. There is a big field for it. It takes a little tact and some knowledge and experience, I believe, to develop that field, and we would appreciate any suggestion that you can give us.

William H. Woods: Mr. Chairman and Gentlemen. Mr. Cousins has practically stated the conditions existing in Toronto in connection with the Toronto Chapter. We are however, not discouraged by any means with the little difficulties encountered in increasing our membership.

Having been Secretary under Mr. Cousins in the organizations of the Toronto Chapter, I have gotten the essential experience in following up prospects for our Chapter. I find that the only way to get members for the chapter is to get out and do personal work amongst the contractors and manufacturing interests, and at the same time try and keep out what we might call deadwood from the chapter. Our policy is to get those vitally interested in our society and present to them simple papers from which good information may be obtained.

I think too, that a good strong point in our chapter meetings is when we have speakers from the large companies over here. We have had some very excellent addresses from Mr. Ward Harrison, Mr. Samuel G. Hibben, Mr. Davis Tuck and Mr. A. J. Sweet, and we are indebted to these gentlemen for the benefit our chapter has derived from their visits. It seems to have consolidated it and shown the membership at large, that there is something really of an international spirit in our Society, and that the chapter has a lot of good information in store for them.

This year our program will be even better than we have presented in the past. We propose going out to our large manufacturing centres and get them to subscribe to our fund, in order that we will be financially sound, I think in that way the committee will not have to worry then, about the necessary expenses involved

in promoting the objects of our organization, and eliminate the undesirable necessity of asking our membership for a subscription, besides our set fees.

Our object this year is to increase the membership of Toronto Chapter to between fifty and sixty members, there are prospects of this additional increase to our roll already lined up by our present secretary, Mr. J. Scott of the Sunbeam Lamp Co. I am sure that when we get working, we will find a good many more prospects about Toronto.

I expect also that Mr. Kintner of the Westinghouse Lamp Co. at Hamilton, who is a member of the Society, with Mr. Stuart, also of the same Company, would like to form a Chapter in Hamilton. Of course they have not the membership in Hamilton to constitutionally form a Chapter at present. These Gentlemen are at present members of the Toronto Chapter, and when the time is opportune, the Toronto Chapter will assist in the organization of a Hamilton Chapter, as that city presents a good field to work in.

G. G. Cousins: May I say just one more word, please? Toronto is reputed to have one of the best Sections of the A. I. E. E. in America, and in comparing their situation with our own, I think the answer lies in the fact that a larger percentage of the A. I. E. E. men are technical school and college men. There are comparatively few men who are educated technically in illumination, in the same way that the electrical men are educated along the lines of the activity of the A. I. E. E.

James M. Ketch: I will have to admit that it was with some hesitation that we broached the plan of organizing a Chapter in Michigan, simply because several of the men had heard from other Chapters that, well, to put it bluntly, the class of stuff that was presented at the Chapters and Sections went over the heads of most of the people who came. And so, we have taken a rather different attitude to this thing.

In order to diversify, we have selected directors from various interests. One man being from the University of Michigan, who maintains the research and the scientific end of that institution; one man from the local architectural society and one of the big architects who maintains our contact with the architects; one man from the central station who maintains that contact; a research man from Dodge Brothers Corporation who is interested in head-

lighting and in headlighting legislation, and also in factory illumination; one man from the National X-Ray Reflector Company who maintains the interest of the sales end of the game; and one man representing fixture and equipment manufacturers.

We have also been fortunate in the past in having a number of these same men belonging to the local Electrical League which they call the Electrical Extension Bureau there, and it is proposed now that in the large technical high school there, they put up a lighting demonstration, which combines the industrial and commercial. It seems now as though this will go across, that there will be put on for the benefit of the technical high school students, a course by the members of the local Electrical Extension Bureau and the Chapter of the I. E. S.

There will be a course put on probably for the local contractors association. One of the directors is also secretary of the local Electrical Contractors Association and he is very much interested that we link up the contractors and Illuminating Engineering Society to iron out some of these old stone age ideas held by some of the so-called contractors.

I see one great difficulty and a thing that we are frankly worried about, and that is in getting the papers. I throw this out as a suggestion: That the national office of the Illuminating Engineering Society keep the secretaries of the Sections and Chapters somewhat informed as to what might be available. Here is a bit of research work going on here, or a large job there; materials that form the subject of papers at the National Society might also well form the subject of papers for the local Chapters and Sections. It might be that the Chapter secretary would welcome once a month, or as they come in, a letter saying that "Here is so-and-so near you who I think would be glad to submit a paper on something that would be of direct local interest to your people."

It is rather hard I will have to admit for a secretary who knows very few people to start right out in a blank field and find papers that are of the calibre that the people who attend the Chapter and Section meetings will understand and something that will be also of news value.

We have also adopted the plan of having one member of the local Chapter attend each of the important, or belong to each of the important associations in the city: the Detroit Engineering Society,

the local section of the American Institute of Electrical Engineers, the S. A. E.; and there is a glorified Electricians' Society. We are represented in all those organizations to maintain the contact for the Chapter and try to bring about cooperative meetings or combination meetings with these various Chapters. We also have an architect's representative belong to our Society as one of our directors.

We can't speak from a whole lot of experience yet simply because we organized last spring, and we hope to have our first paper this month, which we are going to get, if possible, from our retiring President of the I. E. S., on something of a very fundamental and work-a-day kind, something that will start us off in the proper way.

Chairman Law: Is there some one here who can speak for the Northern New Jersey chapter that has just been organized?

Charles Gallo: I think you will find that the electricians, plant engineers, some school authorities, store managers, and people who are selling lighting equipment—all those people who have more or less to do with lighting—are all interested; and if you explain to them in a proper way, just what the Illuminating Engineering Society is trying to do, and how it can help them, I think those people will all join because there are no reasons why they shouldn't. You can convince prospects by properly approaching them, and by constantly keeping at them, emphasizing the fact that the Illuminating Engineering Society can be of great benefit to them, and also that they can be of benefit to the Society, which is unquestionable.

I believe that is about all, but I think Mr. Moore can give a few more details on the organization of the Northern New Jersey Chapter.

Chester L. Dows: I am the outgoing Chairman of the Cleveland Chapter but I am looking forward this coming year to some real work in Cleveland. We have as our new Chairman, Prof. H. B. Dates, Head of the Electrical Engineering Department, Case School of Applied Science. We have as Secretary, Mr. R. A. Fulton, from the Cleveland Illuminating Company, and we have as Chairman of the Papers Committee, Mr. E. W. Commery, National Lamp Works. We hope to increase our membership this year and to diversify it.

The large proportion of our membership comes from the National Lamp Works, where so many are interested in illumination in its various phases. Our problem is one of increasing and diversifying our membership to spread interest in the field of lighting and illumination. We might use profitably any service that brought to our attention suitable speakers and papers from outside our own immediate circle.

During the past year, the Secretary of the A. I. E. E. at Headquarters wrote to all the Secretaries of the Sections, asking for one or two of the most popular papers of the year. Each A. I. E. E. Section has eight or nine meetings through the season and as Secretary of the Cleveland Section, I had no difficulty in picking out two or three outstanding papers to send in to Headquarters. You may expect that a very fine collection of subjects was compiled in this way. A list of these subjects was turned over to the Chairman of the Papers Committee for the year 1923-24 for their consideration.

At Mr. Harrison's suggestion, we started a survey last year of those that might be interested in church lighting. One hundred questionnaires were sent out on which three questions were asked as follows:

1. Would you personally plan to visit a special I. E. S. Meeting at Nela Park, Cleveland, on improving artificial lighting in churches? Yes——— No———
2. Do you believe a sufficient number would be interested in church lighting to make this Meeting a success? Yes——— No———
3. Please give below the names and addresses of men interested in church improvements.

Summary of Twenty-Eight Returns

Question	*Yes*	*No*	*Doubtful*	*Total*
1	14	13	1	28
2	13	12	3	28
3	Fifty-three names and addresses obtained.			

The results of this questionnaire lead us to believe that there was enough interest in this subject to hold a Meeting.

Chairman Law: Mr. Dows, to whom did you send the questionnires?

Mr. Dows: To pastors or their assistants of the larger churches in the city.

Chairman Law: Did you hold such a Meeting.

Mr. Dows: No. This questionnaire was sent out late in the season but we expect to hold this Meeting next year.

Chairman Law: May I ask what you charge for affiliates?

Mr. Dows: We have none.

Chairman Law: Who maintains the Chapter? Who takes care of the expenses?

Mr. Dows: Mr. Commery might answer this question better than I, but my impression is that we have had no expense except for postage, for which we have been reimbursed by Headquarters.

Chairman Law: By the Headquarters of the Society in New York?

Mr. Dows: Yes. Our Meetings have been held either jointly with the A. I. E. E. or in the lecture room of the National Lamp Works, so we have had no rent to pay. Our only expense has been postage.

Chairman Law: I am wondering whether it is not a good plan to establish some set amount for affiliates in Chapters. Of course the Chapter can prepare their by-laws and constitutions, elect their own officers, and really work independently of the Society. But in listening to this discussion, I find that one Chapter charges dues of $1.00, another $2.00, and I can readily see that some might charge $5.00. It seems to me that it would be a great idea to establish some set amount, although, of couse, the I. E. S. Headquarters really has no jurisdiction over this amount.

President Harrison: If you read the Constitution, and particularly the section on Chapters, it will look to you as though the Society created the Chapters and then coldly turned them out to shift for themselves. It says they may arrange their financial affairs just as they see fit, so long as they do not obligate the Society in any way.

To get down to facts, the Sections are supported entirely by the General Office; they ask for a budget at the beginning of the year and it is assigned to them; they send their bills in and they are paid. This means that relatively speaking the Society makes money out of any associate or any member of the Society who happens to reside in a chapter district, because they take his $7.50 or $15 and instead of having to return $2.00 of it—which is the average section expense—they return nothing to the local organiza-

tion. Of course, the members gets the Transactions, but so do the other members. When it seemed evident that the expenses of the Society as a whole for the past year were going to be substantially less than its income, I told the chairmen of a number of chapters that while it was true the Society was not obligated to pay their bills, nevertheless the Society, I knew wanted to deal fairly with them, and if they sent in to the General Office bills not exceeding an average of $2.00 per member I had rather definite hopes that the Council would approve them; I believe the Council has approved them to date. Furthermore, as I recall the Toronto Chapter and the Cleveland Chapter, which were the first ones organized, have a stated appropriation on the books of the Society. I feel that every Chapter should have some appropriation. Of course, the Sections are tied down more closely than the Chapters. They have to hold meetings at stated intervals and do various things, whereas the chapters have more privileges and are more on their own responsibility.

It seems to me that $5.00 is quite a sum to charge for membership in a chapter as long as an affiliate does not get the Transactions. As I recall, for many years the A. I. E. E. chapter dues were $1.00. It seems to me, too, that if a chapter takes in members at a dollar, these same people should not be solicited immediately by the General Membership Committee who would try to advance them to a $7.50 grade; the prospect may just drop the whole thing.

G. Bertram Regar: Mr. Chairman: Speaking from the standpoint of the Membership Committee, the Society has elected 289 members this year. That growth is larger than that of any other year with the possible exception of the first two years of the organization when it reached its peak. Then it grew up as a mushroom, many of those men coming in because of the desire of their companies for co-operation, and they have since dropped out. The slates are absolutely clean today and the report of the Secretary as to the membership shows the Society to be in a very healthy condition.

The Society is for the dissemination of knowledge. I was very glad last night to hear that the lighting man was coming down the hill pretty fast and catching up with the scientist, but if we do not get that information out where it is usable, then the fellow still in back of the lighting man is not catching up with us but is losing ground.

N. D. MACDONALD: Mr. Chairman: I want to say that this meeting has certainly been well worth while. Messrs. Ketch and Dows came here to tell us how badly the General Office was functioning in getting information to them and I stayed over especially to take a "fall" out of some of these section and chapter secretaries because they were not reporting anything to the General Office.

I am talking from the point of view of the Society Transactions. The Committee on Editing and Publications a year ago tried to add to the TRANSACTIONS by putting in some new sections. We felt, considering the figures which Mr. Hibben has given you of 953 persons connected with sections, 337 with chapters, and 181 people not directly connected with any body within the society, that it was time the society had some news-disseminating organ, and therefore, we have tried to put in the TRANSACTIONS such news of the society and of the industry as we could get.

We find a good deal of trouble in getting out the TRANSACTIONS promptly to you because the machinery seems to need a little lubrication. The Section Secretaries are a little bit slow at times in sending in papers; authors do not get them back to us corrected just as promptly as they might, and on that account papers which might be available for your use promptly, are not published for a month or two.

It seems to me that the TRANSACTIONS might be made of great use to you section and chapter men if you would only send us some information about what you are doing in your own chapters. After all, we are not able in the General Office to dig up any more original ideas than you are but if you will send us news of what you are doing and put it in such shape that the other secretaries can use it at later meetings you will have the problen settled.

I just wish to say one other word on that: Won't you please try to send us something that tells us what you really do? Do not write us that "At the Blank Section we held a meeting on such a date. A paper was presented by John Jones. 153 people were present. The paper was enjoyed by all."

Tell us something about what the man said and if there was a fight on the floor, tell us about it. That is interesting and it is news.

Send us some photographs from time to time. Mr. Millar's suggestion is a very excellent one, and if you find items in the daily press from time to time commenting on your meetings or on any new installations, send them in. We shall be very glad to publish them.

J. R. Colville: Mr. Chairman: Mr. Harrison mentioned a few minutes ago that after a chapter is organized it is more or less left out on a limb as far as the parent organization is concerned. I should like to bring up for the consideration of the proper committee the fact that additional instructions in the By-laws and Constitution of this organization would be of very material assistance to a chapter not only in organizing but in carrying on its work. I may be speaking beside the point because perhaps this has been taken care of in the past two years. I organized the Cleveland chapter two years ago and I know at the time, it almost took a lawyer to get out of the constitution the facts as to what we could do and what we could not do. I should like to make the definite, concrete suggestion that the proper committee give consideration to expanding a little bit in the Constitution and By-laws on the matter of chapters so that a person who is really interested can tell without a great deal of digging what the chapter can do and what it can not do.

I am sure, speaking for the men out over the country who do not have the benefit of the Council meetings that a good many of the men who live close by have, that this would be of material help in promoting the chapters. In other words, it strikes me now as though the national body says "If you want to organize a chapter why go ahead; we have no serious objections."

Mr. Moore's paper may clear the whole matter up but I think something should be put in the constitution itself, regardless of whether everything is explained in Mr. Moore's paper or not.

E. F. Nichols: Is there time at this meeting for a moment's digression? It is a matter which, to my mind, applies to the Sections and Chapters and the general society alike. I want to make a comment on the question of the manner of presentation of papers.

There has been one allusion to "highbrow" paper here this morning, and I want to say that the "highbrow" papers at this convention haven't all been given by scientific men. We have had some "highbrow" commercial and "highbrow" art papers too.

The fact of the matter is that the man who gives a paper is usually a specialist and his tendency is to give a presentation which would be suitable to other specialists in his groove. He gives it in a way in which only other specialists in his field can understand it. I think that every man who presents a paper before such a society as ours is under obligation to use his imagination concerning the things in his work which will interest and be within the understanding of his audience.

Papers that are pre-printed have all of the details and all of the facts and all of the technicalities that are necessary. It seems to me that certain very simple rules should be followed in the giving of a paper: The speaker should plainly answer his hearers obvious questions. First, what is he driving at? That he should give in plain, simple English so that a man in the street or in the alley, even, can get some notion about it. How is it connected up with other things that are nearest it? What are its surroundings? Second, why is it worth driving at? Third, how is he driving at it? Fourth, what did he find at the end of the road? And let it go at that. If any member is interested in any particular or further details, such matters can be brought out in the discussion by the members who have read the pre-printed paper. But I think in giving the paper orally, it ought to be given in such a simple, straight-forward way that the audience will not only get the benefit of the paper itself but will know what its closest relatives are and why the work was worth doing and worth reporting.

PRESTON S. MILLAR: At our annual conventions advancement of the science and art of illumination is discussed by the leaders in the illuminating engineering field. It is very rare for enough of these leaders to gather at a meeting of a chapter to make such discussions practicable. The Northern New Jersey Chapter of the Society is organized with the idea not so much of furthering discussions for the advancement of the science and art as for the purpose of taking to those who can influence the practice of the public such ideas as have been worked out in the Society's technical meetings and promoting their application in practice. Thus the Chapter seeks to hold meetings with civic bodies, trade organizations, church organizations, etc., for the purpose of pointing out how illumination in their respective provinces can be improved to their advantage.

It seems to me that additional chapters organized for scientific discussion of the lighting problem will not succeed. Chapters organized for the purpose to which the Northern New Jersey Chapter is committed can perform a valuable service in extending the influence of the Society for better lighting by the public.

In the conduct of Sections, Chapters and Local Representatives' work there is a very evident need for a co-ordinating influence from headquarters. It seems to me that there ought to be an individual or a committee charged with following the work of each and communicating to the others information of a promotive character.

RAILWAY CAR LIGHTING*

BY GEORGE E. HULSE**

SYNOPSIS: Limitations encountered in the problem of supplying illumination to cars. Amount of energy available limited, due to car being on the move. Position of lighting fixtures determined by car construction, preventing flexibility in placing units.

Maintenance of reflecting and transmitting surfaces more difficult than in most other situations.

MEANS OF LIGHTING—

Gas—incandescent mantle.

Electricity—axle driven generator with storage battery.

STANDARDIZATION OF CAR ILLUMINATION—

The postal car lighting tests of 1912.

Determined and standardized.

The amount of illumination necessary for postal clerks to properly handle mail.

The types of reflectors best suited for use.

Based on these test results, the Railway Mail Service issued specifications for lighting of postal cars, giving definite values for their illumination and other details, such as mounting height of lamps, and angle of cut-off.

These specifications can be applied without the necessity of further investigation, in the case of the change in interior design of postal cars, the type of reflector available, or the type of light source available.

COACH LIGHTING TESTS OF 1913—

Determined the amount of illumination obtained with the possible arrangements of fixtures, and the available types of reflectors, bowls and lamps.

The results of these tests are still in use as the basis for designing lighting installations in practically all classes of cars.

ARRANGEMENT OF FIXTURES FOR VARIOUS TYPES OF CARS, AND THE RESULTING ILLUMINATION—

Coaches, Dining cars, Sleeping cars, Postal cars, Business cars, Baggage cars, Parlor smoking cars.

TYPES OF GLASSWARE USED AND THE EFFICIENCY OF INSTALLATION WITH THIS GLASSWARE—

Illumination values obtained. The illumination obtained runs lower than illumination values used in office or factory installations, but seems to be ample for the conditions under which it is used.

The special conditions surrounding the generation of light, and its application for obtaining correct illumination in car lighting, differentiate it considerably from other forms of lighting and illumination.

The amount of energy which can be used for lighting is limited. This energy can be obtained from a stored supply, or it may be

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generated on the car itself, which also entails obtaining it at times from a stored supply. This limitation in the amount of energy available makes its most efficient utilization necessary.

The lighting fixtures must be permanently secured in position, and out of the way of seats, baggage racks, and sleeping car berths, and their position is also determined by the actual conditions of car construction. This limits the flexibility possible in placing the units.

The problem is further somewhat complicated by the fact that the fixtures must be maintained with the minimum of labor expended in their upkeep, and as the conditions on a railroad car are particularly bad as regards the collection of dust and dirt on the fixtures, this item is one which has had careful study in the designing and placing of the lighting units.

METHODS OF LIGHTING

A large number of cars are at present, and will continue for some time to be lighted by gas. Practically all gas lighted cars in this country use oil gas as the illuminant. This gas is made by 'cracking' petroleum oil in generators. After it is put through the usual processes of cleaning and purification, it is compressed to a pressure of about 150 pounds per square inch, and is distributed under this pressure to the car yards, where it is transferred to suitable holders carried underneath the cars.

This gas has a high heating and illuminating value, which is not materially decreased by the compression to which it is subjected. It is this feature of the gas which makes it suitable for car lighting, as it provides the maximum amount of lighting value.

Most of the cars lighted by gas use the incandescent mantle, and the flat flame type of lamps which were installed in the older cars are being converted to use the incandescent mantle. The largest proportion of the lamps use a mantle giving 90 cp. and consuming 2 cu. ft. of gas per hour. Where the lamps were originally installed at considerable distances apart, when the lamps are remodelled it is not feasible to respace the lamps, a large mantle giving 125 cp. with a consumption of 2.5 cu. ft. of gas per hour is used. A smaller mantle, giving 25 cp. is available for use where smaller light sources are necessary.

The mantle, being of the inverted type, gives a candle power distribution which is well suited for the requirements of car lighting.

As the gas is of constant quality, and the pressure maintained is very uniform, the light output of the mantles is constant, and is maintained without any necessity of adjusting the air or gas supply.

Electric Lighting

A large proportion of the new cars now being built are fitted with electric light. In some cases, electric light is also being applied to older cars, displacing the former systems.

The Axle Generator System is almost exclusively used for generating the electricity for lighting cars.

The system known as the 'Straight Storage System' was formerly used to a considerable extent, but it has almost entirely disappeared. With this system, the light was obtained from storage batteries which were charged at a stationary plant, necessarily while the car was not in operation. This system has gone out of use, because the time required for charging the batteries lessened too much the availability of the cars for actual service, as it required an actual charging period of eight hours to properly charge the batteries.

Some trains are still lighted by the 'Head End System,' in which the current is obtained from a steam driven generator in the baggage car of the train. This generator supplies the current for the whole train. A few of the cars in the train are supplied with storage batteries to take care of the lighting during such times as the engine is detached. This system, however, is going out of use. In the winter time the steam used by the turbine is too much of a drain on the locomotive, which, at certain times, needs all the steam supply which it can generate to pull the train. This system is also quite inflexible, as it provides no means of lighting cars which may be detached from the train and sent to branch lines.

In the Axle Generator System, the current is generated by a dynamo driven from the axle of the car. This dynamo provides current for the lights, and charges a storage battery which provides current for lighting when the car is not in motion. With this system, each car is its own power plant, which is in operation whenever and wherever the car may be in service.

Such attention as is necessary for the proper operation of the system may be given to the car during the time of its regular layover periods.

The essentials of such a system are as follows:—(1) A generator mounted on either the car body or the truck with some form of driving system between the car axle and the generator. (2) A storage battery to furnish current when the car speed is not sufficient to drive the generator at a speed to properly charge the batteries and light the lamps. (3) A regulator to govern the output of the generator at varying speeds, and to properly charge the storage battery and protect it from overcharging. (4) A regulator to maintain proper voltage at the lamps. (5) Some means of keeping the polarity of the generator constant, when the direction of movement of the car changes.

These conditions have been successfully met in various ways, the majority of equipments in use now embodying the following features:—(1) A generator mounted on the car underframe, driven by a belt. (2) The generator is controlled for output at varying speeds by a carbon pile rheostat in its field circuit. (3) The battery is protected from overcharging by the voltage which is supplied to it being limited to a voltage which will properly charge the battery but will not overcharge it. (4) The lamp voltage is held constant by an automatic carbon pile rheostat.

At present, there is some demand for a drive which will be more positive in its action than a belt. Belts do give some trouble from slipping, and from being lost, especially in winter weather. Various types of gears or other positive drives are being investigated, but it is doubtful whether when all the conditions of application to the car, first cost, and the cost of maintenance are considered, the increase in service will be justified.

CAR ILLUMINATION

I have already said that the mounting positions for the lighting fixtures in railroad cars are limited—in fact, there are practically only two positions in which the fixtures can be placed. These are:—(1) On the upper deck, that is, dirctly under the roof of the car, or (2) on the side deck. As the ceiling height is only nine feet, it is impossible to keep the light sources out of the range of vision, and makes the screening of all light sources absolutely necessary.

While these limitations may have led to some inconvenience, they have also accomplished the adoption of certain standards for lighting cars, which must be very closely adhered to.

There are standards in use for the illumination of almost every type of car, and these standards are based on data obtained from tests made in cars with all possible combinations of fixture positions, light sources, and fixture accessories.

Postal Car Lighting Tests

In 1912, the Post Office Department, represented by the Railway Mail Service, together with a number of Railroads and manufacturers, conducted a series of tests at Washington to determine what was the proper illumination for postal cars, and how it could best be obtained. These tests included the measurement of illumination with all available arrangements of fixtures, light sources, reflectors, and glassware. They also included tests of the amount of illumination necessary for the postal clerks to do their work properly and without eye fatigue. These latter tests were made with a large number of operators, and with all possible combinations of fixture positions, light sources, reflectors and glassware.

As a result of these tests, specifications were issued by the Post Office Department covering completely the lighting of postal cars, as to the general position of the fixtures, and the amount of illumination necessary in different parts of the car, the latter being given a maximum and a minimum value. Differentiation was also made between the different types of reflectors, and where the tests showed that the illumination necessary differed with one type of reflector and another, proper allowances were made in the specifications.

The application of these specifications has resulted in a very satisfactory illumination of postal cars, and although since these tests were made the types of light sources have changed, the interior construction of the car has been modified, and new types of reflectors have been introduced, the information obtained, and the standards adopted as a result of these tests, have made it possible to rearrange the illumination and give satisfactory results without the necessity of any further investigation.

Following the postal car tests, a number of Railroads and manufacturers interested, conducted a series of tests on the lighting of railroad coaches at Cleveland. In these tests, the amount of illumination with all possible arrangements of fixtures and available types of reflectors and bowls and light sources, was determined. The results of these tests were sufficiently comprehensive to cover all the features which have been introduced in car lighting since that time, and are still in use as a basis for designing the lighting installations in practically all classes of cars, except postal cars.

TYPE C LAMP

The introduction of the type C lamp with its larger output of light per unit of energy has, of course, had some influence on car lighting where the question of efficiency in the light source is particularly important.

Up to the time of the introduction of the type C lamp, the use of open reflectors was universal for almost all of the different classes of cars. This was used on account of its increased efficiency over any enclosing bowl, and also on account of the fact that it was considerably easier to keep clean than enclosing glassware. Indirect lighting has never been used to any extent in car lighting due to the difficulty in keeping the reflecting surfaces in proper condition. The appearance of the fixture with open reflectors, is, of course, not so pleasing as fixtures with enclosing bowls, and the proper screening of the light source in considerably more difficult.

Since the introduction of the type C lamp, however, the use of enclosing glassware is increasing, as about the same output per unit of energy used can be obtained by using enclosing glassware with the type C lamp as can be obtained with the open reflector and the type B lamp, and the appearance of the former type of fixture is considerably better than the open reflector.

Type C lamps are being used to some extent in open reflectors, but this is not good practice, unless the lamp is white glass, or bowl frosted, as, even if the light source itself is screened, the bright reflection spots on the reflector are very trying to the eyes.

The following is an outline of the methods of lighting used in the various types of railway cars—

Coaches

Coach lighting is, of course, of the greatest importance as, coaches constitute the largest number of cars in use, and carry more people than any other class of car.

A certain amount of general illumination is necessary, but the principal illumination is required for reading. The lighting system should be designed for best illumination on the reading plane, which is 45° to the horizontal, and at right angles to the centre line of the car. The lighting tests which I have referred to, demonstrated that equally good illumination, as far as intensity, distribution, and uniformity go, could be obtained either with the fixtures mounted on the upper deck, or on the side deck.

Centre lighting is more largely used, however, on account of the fact that it requires less fixtures, and there are fewer lamps and reflectors to maintain. Centre lighting also gives less trouble from shadows cast by the passenger's head on his own or another passenger's reading. The standard spacing for lamps is 6-ft. both for those mounted on the centre deck and on the side deck. The mounting height for the centre lamps is about 8-ft. and for the side lamps 6-ft. 6-ins.

The open-mouth type of reflector, in either heavy density opal glass, or clear prismatic, is employed for coach lighting, preferably with type B lamp. For centre lighting, a 50-watt lamp is used, having an output of 560 lumens, and for the side lighting a 25-watt lamp, having an output of 270 lumens.

Using these lamps, the following illumination values are obtained with the open- mouth reflectors as in Table I.

TABLE I

FOOT-CANDLES

	45° PLANE			HORIZONTAL	EFFICIENCY PER CENT
	Window Seats	Aisle Seats	Mean	Average	Horizontal Plane
Heavy Density Opal	2.87	3.85	3.39	4.95	49.7
Clear Prismatic	2.81	3.67	3.25	4.67	46.6

When type C lamps are used, they should be used exclusively for centre lighting, in fixtures placed close against the ceiling with an enclosing bowl, the mounting height of the fixtures being about 8-ft. 6-ins.

The bowls used are of the best type of transmitting glassware, and the lamps 50-watt type C, with an output of 740 lumens. With the grade of glass now available, the following illumination values are obtained—See Table II.

TABLE II

FOOT-CANDLES

45° PLANE			HORIZONTAL PLANE	EFFICIENCY PER CENT
Window Seats	Aisle Seats	Mean	Average	Horizontal Plane
2.59	2.85	2.72	3.35	22

Using the 75 watt type C lamp (1215 lumens, or 202 lumens per running foot of car) these values would be as follows—See Table III.

TABLE III

FOOT-CANDLES

45° PLANE			HORIZONTAL PLANE	EFFICIENCY
Window Seats	Aisle Seats	Mean	Average	Horizontal Plane PER CENT
3.58	3.44	3.75	4.65	22

It will be noted that using the same wattage the values obtained with the type C lamp and enclosing bowls are about 20 per cent lower than with the open-mouth reflectors. With the enclosing bowl, to obtain illumination equal in intensity to that obtained with a type B lamp and open-mouth reflectors, it is necessary to increase the wattage 50 per cent and to use a type C lamp. With the enclosing bowl, there is no danger of glare, and the appearance of the car is considerably improved.

With gas lighting, the lamps are generally spaced 9-ft. apart. The best arrangement uses an enclosing bowl around the mantle, as open-mouth reflectors are not suitable for use with gas burners. The type of bowl most generally used is one that is spherical in

shape, the upper half being of heavy density opal glass, and the lower portion of clear glass optic ribbed. As the gas mantle has a rather low intrinsic brilliancy, these ribs give sufficient diffusion to prevent any bad effects from glare. The illumination values for a coach with such an equipment, using the 90-cp. mantle with 9-ft. spacing, 87 lumens per running foot of car, are as follows as in Table IV.

TABLE IV
FOOT-CANDLES

45° PLANE			HORIZONTAL PLANE	EFFICIENCY PER CENT
Window Seats	Aisle Seats	Average	Average	
1.75	2.04	1.89	2.42	25

With the 125 c.p. mantle, giving 120 lumens per running foot of car, these values would be as follows—See Table V.

TABLE V
FOOT-CANDLES

45° PLANE			HORIZONTAL PLANE	EFFICIENCY PER CENT
Window Seats	Aisle Seats	Average	Average	
2.44	2.84	2.64	3.37	25

Dining cars

The evolution of dining car lighting is an example of the fact that the type of lighting which may be satisfactory in one place may not be satisfactory under what appear to be very similar conditions. It is generally conceded that the requirements for dining room lighting are that the table itself should be made a place of high illumination, and that the remainder of the room should be at a considerably lower level.

Some years ago a system of lighting dining cars was designed, based on these requirements, and this system met these requirements fully. However, it did not give satisfaction to the patrons of these cars. The lighting fixtures were placed directly over the tables, with concentrating reflectors above the lamps, and directing

plates under the lamps, placing a high illumination directly on the table. The general illumination was quite low, and was obtained by a few light sources in the upper deck of the car. While the tables were very well lighted, the rest of the car, of course, was not, and patrons of dining cars complained that the cars were gloomy. This has led to an installation, in which there is a considerable degree of general illumination. The lamps over the tables have been retained, but the general illumination is now of a higher value, and is obtained either by semi-indirect lamps, or by enclosing bowls, placed directly against the ceiling. The lamps for general illumination are mounted 6-ft. apart, and use 50-watt type C lamps. The illumination on the table top is from eight to twelve foot candles, and is obtained by the use of 50-watt type C lamps, mounted in the special fixture referred to.

The kitchens and pantries in the dining cars, of course, require a high degree of general illumination, as they are so small that the work of preparing meals is carried on in all parts of these rooms. The present practice is to light these rooms by ceiling fixtures, using a 50-watt type C lamp with a reflector of the RLM type.

As the work is carried on by the occupants of these rooms in a standing position, and this work is all below the level of the eye, this type of fixture can be used without any bad effects from glare.

Sleeping cars

Sleeping cars require lighting for general illumination, for reading, or for working at a table in the sections, for the illumination of the berths after they are made up, and for the illumination of the aisle for passengers who go through after the berths are made up.

The fixtures for general illumination must be placed close to the ceiling to prevent interference with the fixture from the upper berth. A shallow enclosing bowl is used with these fixtures.

Small units, with individual control, placed in the corner of each section, provide additional local illumination for reading in the seats, and for the necessary light after the berths have been made up.

The state rooms in a sleeping car and compartment car are lighted by the same type of ceiling lamp as is used in the berth section of the sleeper.

Smoking rooms are lighted by centre lamps in the ceiling, and also may have bracket lamps at the back of the fixed seats to ensure proper lighting for reading.

The passageways are lighted by ceiling fixtures, either with open-mouth reflectors, or a fixture having a reflector set into the ceiling, and a directing plate under the lamp set flush with the ceiling.

It was formerly the custom to leave one or more of the centre lights lit after the berths had been made up, but this, of course, was a nuisance to the occupants of the upper berths. Fixtures are now being used which are secured to the frame of the seat. These fixtures throw the light on the floor, making it easy to find the way along the aisle after the berths have been made up, and the ceiling lamps have been extinguished.

For the centre lamps, type C bulbs, 100-watt, having an output of 1700 lumens, are used. The general illumination on the reading plane with this fixture and 100 watt bulb, averages five foot candles. For the berth lamps, 25-watt type B bulbs are used.

Parlor cars

Parlor cars require illumination mainly for reading purposes, together, of course, with sufficient general illumination. The same type of installation is used in parlor cars as in sleeping cars, with, of course, the omission of the particular units having directly to do with the sleeping car berths.

Parlor-smoking cars

These cars require general illumination, and also good illumination on the reading plane. The general illumination is obtained by the same type of centre fixture as is used in sleeping cars, but as the seats are on the side of the car facing the centre, it is necessary to add to this illumination for reading purposes. The additional illumination is obtained either by pendants attached to the side deck, or by brackets on the side walls of the car.

Postal cars

The proper illumination of a postal car is, of course, very important as postal clerks are employed constantly while in the car on work which demands the best possible illumination.

Postal cars are divided into three sections—

(1) The section where the letters are taken from the sacks and distributed to the pigeon holes according to the route which they are to follow.

(2) The bag distributing rack, where the papers are distributed into boxes, and where packages or letters are placed in the mail bags.

(3) The storage end, where the filled sacks are stored.

The letter distributing cases require high illumination on the vertical plane for the box labels, and on the horizontal plane for the reading of the addresses on the mail.

The bag distributing racks require high illumination on the horizontal plane, for reading the addresses on the packages, and also for the labels on the bag rack.

The storage end of the car requires a fair general illumination. The following are the specifications of the Railway Mail Service for the initial illumination values for the various portions of the postal car as in Table VI

TABLE VI

INITIAL VALUES OF ILLUMINATION REQUIRED

	FOOT-CANDLES	
Bag Rack Portion	Minimum	Maximum
Centre of car—horizontal	3.75	12.00
Mouth of bags, measured 18 inches from side of car—horizontal	2.00	12.00
Letter-cases		
Over table—horizontal	3.75	19.00
Face of case—vertical	1.66	19.00
Storage portion	2.00	12.00

These initial values are so set so as to give adequate illumination in case there is a depreciation of 40 per cent in the efficiency of the installation.

If reflectors with a glazed reflecting surface, such as porcelain enamelled metal, are used, these values must be increased 25 per cent.

The reflector most largely used in postal car lighting is one made from aluminum, with a special matted surface, which gives

a high reflecting efficiency, and which may be easily cleaned, and its original efficiency restored.

These specifications are fulfilled in the 60-ft. postal car of the present type, by using 15 type B 50-watt 560-lumen lamps. These lamps are used with an aluminum open-mouth reflector, the reflector at the lettercase being of the intensive type, and those in the bag rack and storage portion, giving the maximum outputat an angle of 45°.

If type C 50-watt lamps are used, eleven lamps are required. These lamps have an output of 740 lumens. The same type of reflector is employed.

The Railway Mail Service require that if the type C lamp is used, it must be bowl frosted, or enamelled.

For the 60-ft. apartment, with Pintsch gas, eleven lamps are required, using a 90-cp. mantle, with aluminum reflectors.

Private or business cars

The private or business cars generally consists of what may be termed the living room, or office, in the observation end, several state rooms, or bedrooms, dining room, and kitchen.

The living room or office, is provided with general illumination from centre lights. It may have chairs placed along the side facing the centre, and lighting for reading at these chairs is provided by brackets on the side wall, or pendants on the lower deck. Adjustable local lighting units are provided for the desks and typewriters with which these rooms are generally fitted. There are also local lights provided for lighting the gauges and speed indicators which are installed in this room.

The bedrooms may be fitted either with the ordinary form of sleeping car berth, or with a portable bed. These rooms generally have one centre lamp. If there are berths, the berths are provided with berth lights, and the beds have reading lights attached to the bed posts. The mirrors in these rooms are provided with local lighting brackets set on either side of the mirror. The centre lights used are generally of the enclosing bowl type, mounted close to the ceiling.

The dining room is ordinarily lighted by one centre light placed directly over the table. In some cases, the dining room may be also used for a sitting room. In this case, additional lighting is provided by brackets or pendants on the deck rail.

Baggage Cars

These cars must be provided with good illumination both on the horizontal and vertical planes.

The illumination on the vertical plane must be of a good value up to a height of seven feet. Trunks, and other articles, which are carried in baggage cars, are often piled very high in the car, and the illumination must be sufficient so that the labels, or markings, on all baggage can be easily read.

Glass reflectors, or enclosing bowls, are not desirable in this class of car on account of the danger of breakage.

The best practice at present is the use of metal reflectors of the RLM type, placed as close to the ceiling as possible. With such reflectors, and 50-watt, 740 lumen type C lamps, spaced 10-ft. apart, an illumination of about four foot candles will be obtained on the horizontal plane, and an illumination varying from one to five foot candles on the vertical plane.

Baggage cars should also be provided with a fixture over each door, having a metal reflector designed to light the floor of the car directly at the door, and also to reflect the light through the doorway of the car so that it may illuminate the floor of a baggage trunk placed at the doorway.

ILLUMINATION INTENSITIES

I have heard at times some criticism of the intensities of illumination which are obtained in car lighting, with the suggestion that these should be considerably increased in line with the increase in intensities in other lines of work.

With the best installations, in coaches the illumination on the horizontal plane will be about four foot candles, and on the 45° reading plane, will average about three foot candles.

In sleeping cars, with the present arrangement of lamps, the light on the 45° reading plane will average about five foot candles.

These values are, of course, lower than those recommended at present for the lighting of offices and similar rooms. It must be considered, however, that cars, with the exception of the baggage car, postal car, and kitchen of dining or business cars, are not used to any extent for work. The illumination is used principally for reading for short spaces of time. In view of this fact, these intensities of illumination seem to be adequate. The intensity obtained in Pullman cars at present is certainly sufficient for any use to which it is put.

In the case of postal cars, the horizontal illumination obtained with the new installation is about six foot candles, although the specifications based on actual tests and study of the problem, allow for a considerably less intensity than this.

As I have already said, the amount of energy available for use on the car is limited—therefore, the illumination provided must of necessity be as low as possible and still be adequate. The illumination obtained, however, from the best practice at the present time appears to be quite adequate.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

THE FIRST LOW VOLTAGE GAS FILAMENT LAMP*

BY D. MCFARLAN MOORE**

SYNOPSIS: For many years all luminosity due to the action of electricity in gases was associated with high voltages. The light between the two terminal electrodes of a small Geissler tube, or of a tube lamp such as used in the Moore long tube system, is positive column light, which in a measure accounts for its much greater intensity and efficiency. Several years ago it was found that luminosity in gases could be produced solely by voltages as low as 110, but it was a negative glow light of low intensity that surrounded the metal electrodes in a bulb of rarified neon gas. Although the ice on the problem was broken by the negative glow lamps, there remained the far more difficult problem of obtaining positive column light on low voltages. This paper announces such lamps, and contains, also, a brief resumé of the history of gaseous conduction and its many contacts with electrochemistry

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It has been questionable from a scientific standpoint whether or not it would ever be possible to obtain a positive column lamp which will start and run on potentials less than 220 volts, but such a lamp is described in this paper.

The basic principles upon which it operates are such that hopes are entertained that it can be developed into a new and very useful light source. The steps leading up to this result have been interesting, and I have been requested to touch upon some of the high points in gaseous conduction lighting and keep in mind the various electrochemical problems involved.

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Large tube lighting units have their commercial limitations, however, whether built *in situ* or in portable form, so that once

*Abstracted from a paper presented at the Forty-fourth General Meeting of the American Electrochemical Society, Dayton, Ohio, September 27, 28 and 29, 1923.

**Moore Light Dept., Edison Lamps Works of G. E. Co., Harrison, N. J.

more the desire for a simple bulb form of electric gas lamp became acute, and the first low voltage gas lamp already referred to resulted. However, the possible candle-power on 110 volt from such neon corona lamps was meager, and, therefore, the commercial possibilities restricted.

Higher candle-powers were reached in another new type of low voltage lamp*, in which the light emanated simultaneously from three sources: (1) the neon gas, (2) the tungsten arc, and (3) the more or less highly heated tungsten electrodes.

It was realized that if a positive column could be made by 220 or 110 volts it would probably have long life due to the small tendency of a positive column to blacken, and also that it could be made bright and efficient. But with ordinary electrodes, of iron for example, 220 volts even in neon gas would not produce any positive column light, and therefore special expedients needed to be devised that were simple, that is, that did not involve the use of a high potential transformer or other auxiliary apparatus. Figure 1 is a photograph of one of these new low voltage positive column lamps, that is immediately applicable to any 220-volt a. c. socket. Figure 2 indicates its construction as well as one form of circuits that involve the fundamental principle of first generating in a short gap the electrons needed by the long positive column.

The line potential on 1 and 2, which are attached to the cylindrical electrodes 4 and 5, can not normally produce any current or any light through the long positive column 3; but there is provided the electrode 6, that is less than 1/64 inch from 4 and it is connected to a similar electrode 7, so that the 220-volts immediately bridges the gaps 6-4 and 7-5, thereby generating electrons which then cause the 220-volts on 4 and 5 to produce a bright discharge through the positive column 3. One of the definitions of the word filament is "something continued in a long course" and since, when viewed from a short distance such a positive column discharge does not look unlike the carbon filament of a former type of series lamp, the term "gas filament lamp" has evolved in contra-distinction to a solid filament lamp. It will be noted that the gas filament is confined within a simple curved glass tube which has an opening or vent at its center. Since the bulb is supplied with neon gas at a

*A low voltage self-starting Neon Tungsten arc incandescent lamp. Trans. Am. Inst. Elec. Eng. Sept. 26, 1921.

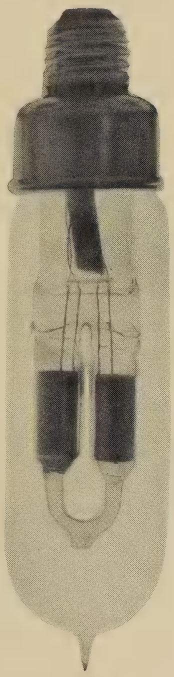

Fig. 1—Moore low voltage positive column gaseous conductor lamp, 220 v.

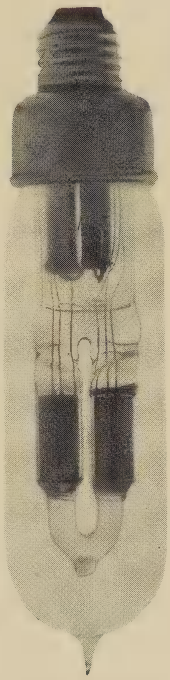

Fig. 3—Moore low voltage positive column gaseous conductor lamp, 110 v.

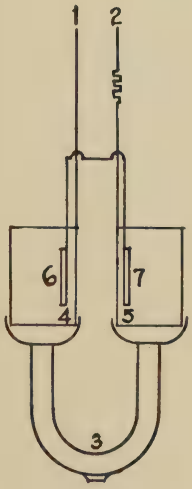

Fig. 2—Low voltage (220 v.) positive column lamp.

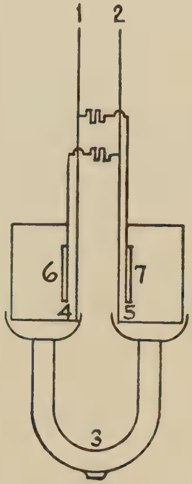

Fig. 4—Low voltage (110 v.) positive column lamp.

pressure of about 20 mm., this vent not only tends to regulate automatically the gas pressure, within the filament tube, when it is warmed by the discharge, but also prevents electrode impurities, though small, from seriously affecting the gas filament conductivity. It might be called a self-healing or self-repairing conductor.

Figure 3 is a photograph of such an experimental gas filament lamp suitable for 110 volts and Figure 4 is a diagram of its construction and circuits. It will be noted that in the 220-volt lamp there are two ionizing gaps in series, and in the 110-volt lamp the gaps of each electrode are in multiple, which dispenses with all wasteful positive column resistance. A large number of modifications of both circuits and electrodes have been tried, with wattages varying from 1 to 100.

Life tests have proven that some of these lamps have, without appreciable change, run for over 400 hours. But it is not claimed in any sense that this new type of lamp has reached a commercial stage. This paper is written merely as a means of recording scientific advance in what has been claimed to be an important direction. Theory seems to indicate that to increase materially the luminous efficiency of light sources in general, resort should be made to radiation from gases electrically agitated.

Perhaps the exact and complete theoretical explanation of the action of these lamps is not now known, but it may suffice to say that at a definite line wattage consumption, a given lamp may satisfactorily operate without apparent change for several hundred hours, yet if operated at about 30 per cent lower watts its positive column will cease, due to lower gas pressure, and if it is operated at about 30 per cent higher watts its positive column will also cease, but due to too high gas pressure. These actions suggest the query whether or not at the medium wattage there is going on a simple consumption of the electrode material, or is there a definite electrochemical cycle comparable to that of the mercury tube light.

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SOCIETY AFFAIRS

THE LAKE GEORGE CONVENTION

"All work and no play make Jack a dull boy" apparently was one of the principles followed by the committee in charge of the Seventeenth Annual Convention of the Illuminating Engineering Society at Lake George, September 24th to 28th. The Fort William Henry Hotel served as headquarters to the largest assemblage its staff has ever known. Many nearby cottages and smaller hotels were called upon to house the throng.

An elaborate entertainment program alternated with the many business sessions which were held from day to day. Especial pains were taken to provide social events for the women guests. The Glens Falls Country Club allowed free use of its privileges to the delegates.

A business session was held Monday afternoon and the usual procedure of getting acquainted was followed, the day culminating in an informal dance in the hotel at night.

THE NIGHT OF LIGHT AND COLOR

One of the outstanding features of the session was a lecture, "Light", given by M. Luckiesh, of the National Lamp Works of the General Electric Company, Cleveland, at which time he introduced a special lantern for illustrating his talk. This device throws a kaleidoscopic color pattern on a screen, constantly changing to new designs, and proving of invaluable assistance in developing new color schemes. Various color cylinders are inserted in the machine and the resulting designs on the screen will not duplicate themselves if the apparatus is run constantly for 24 hours.

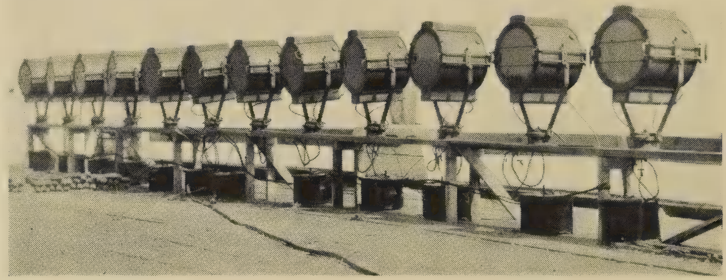
The lighting and fireworks spectacle the night of September 25th was the grand climax of the convention. Visitors from the surrounding country up to 75 miles away poured into the village during the latter part of the afternoon and early evening and took up positions on the shore of the lake for miles to view the display. It was asserted by state troopers who handled the traffic during the general exodus following, that only with the greatest difficulty was the string of automobiles kept moving, hours being consumed in emptying the region of visitors.

THE OUTDOOR DISPLAY

A multicolored lighting and fireworks spectacle designed by W. D'Arcy Ryan and unequalled since the Panama-Pacific International Exposition was the outstanding feature of the seventeenth annual convention of the Illuminating Engineering Society at the Fort William Henry Hotel, Lake George, N. Y., September 24th to 28th, inclusive. Over 300 members and guests of the Society were present at the gathering, and it is estimated over 50,000 viewed the lighting and fireworks display the night of the 25th.

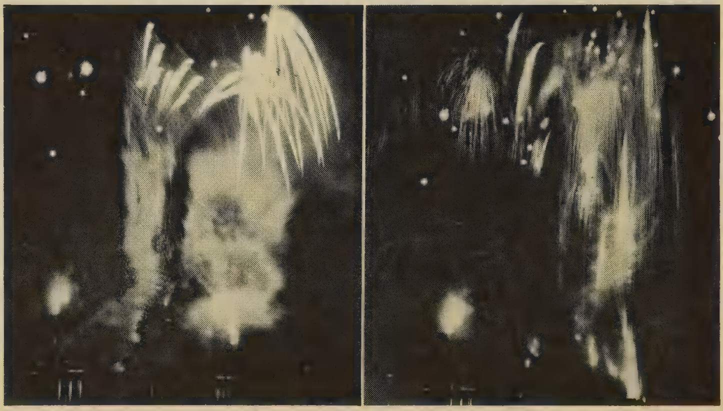
Excursion Boat—Tuesday Afternoon Session

Apparatus on Pier for Fireworks and Steam Effect



Searchlight Battery

Fusing Sky-Rocket Battery



Fireworks—Night of Light and Color

For a number of days previous to the opening of the Convention, workmen nd engineers were busy arranging the spectacular light and color effects which rere introduced. This work was carried on under the general direction of W.)'Arcy Ryan, Chairman of the Convention Committee, and his assistants. A rell-drilled corps of about 50 men was required to operate the many search-ghts, colored torches, lanterns and fireworks which were utilized. Set pieces, iortars for discharging bombs, rockets and red fire were included in the yrotechnic display.

The trees and shrubbery about the hotel and grounds were gorgeously luminated by colored searchlights placed in advantageous positions, various iades and hues enchancing the natural beauty and form of the growth. One ree, bathed in rainbow tints by searchlights placed directly beneath, was an xample of unusual chromatic beauty. It was in this work that Mr. Ryan xcelled himself and more than sustained his reputation gained in the past for plendid effects of this nature. Torches were placed along the paths and olored lanterns hung in the groves. A jeweled emblem of the society, bedecked rith glass pendants and brilliantly illuminated by a single powerful beam from ne of the largest searchlights in use, formed a point of splendor in the trees.

This light and color combination on the grounds of the hotel formed the itroduction to the fireworks display which followed. It was during the ex-ibition that there was called into use the famous Ryan color scintillator which ras so successful at the San Francisco exposition. A dozen beams from as iany searchlights, varied and changing in hue, formed designs of unusual eauty both on the clouds of smoke formed from the bursting bombs and reworks, and with the aid of steam especially generated for the purpose. To his end, a Delaware and Hudson R. R. locomotive was utilized. Some of ie effects gained in this manner were "Aurora Borealis," "Fighting Serpents nd Chromatic Wheel," "Beam Drill," "Plumes of Paradise," "Spooks' 'arade" and "Devil's Fan."

Another feature of the pyrotechnic program was the use of twelve-inch Lyan electric shells, which are among the largest ever used in such displays. 'he release of these and others ranging down to four inches in diameter was iade from a total of 150 mortars arranged upon the steamship dock. Float-ig figures of animals, parachutes and flags were released from some of the ursting bombs. These were picked up by the many-colored searchlights and ieir descent illuminated.

The Convention Banquet was held on Thursday evening at which General ieorge H. Harries officiated as toastmaster. The main address was given by Ir. Laurence A. Hawkins of the Research Laboratory of the General Electric 'ompany.

One of the most pleasant surprises at the banquet was the presentation f the Past-President Badge to those Past-Presidents of the Society in attend-nce at the Convention. This badge is the regular design of the member adge and is made in gold with no enamel.

CLEVELAND AGAIN WINS ATTENDANCE PRIZE

The customary feature of the annual banquet was observed in the pre-sentation of the traveling gavel to the Cleveland Chapter by Mr. D. McFarl Moore for the largest representative attendance at the Convention. M E. W. Commery accepted the award in a fitting manner.

SECTION ACTIVITIES

LOS ANGELES CHAPTER

At a meeting of the members of the Illuminating Engineering Society he at the Alexandria Hotel, Los Angeles, on September 24, the following office were elected for the year 1923-24 for the new Los Angeles Chapter of th Society: *Chairman:* David C. Pence, Manager of the Illuminating Dep Illinois Electric Company, Los Angeles; *Secretary-Treasurer:* J. F. Anderso Illuminating Engineer, Southern California Edison Company, Los Angele *Directors:* F. S. Mills, Western Representative of the National X-Ra Reflector Company, Los Angeles; Herbert J. Mayo, Sales Engineer, Be jamin Electrical Manufacturing Company, Los Angeles; Walter A. Alde Interior Lighting Engineer, Westinghouse Electric & Manufacturing Com pany, Los Angeles.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council, September 27, 1923, the following we elected to membership:

Four Members

Fales, Thomas C., President, Dedham & Hyde Park Gas & Electric Light Co 60 Congress Street, Boston, Mass.

Loomis, Franklin Wells, Illuminating Engineer, Duquesne Light Co., 4 Sixth Avenue, Pittsburgh, Pa.

Toensfeldt, Ralf Thomas, Chief Electrical Engineer, Dept. Public Utilitie City of St. Louis, Mo.

Willcox, Francis Wallace, Manager, International General Electric Co 120 Broadway, New York, N. Y.

Eighteen Associate Members

Bishoff, Alexander, Assistant Examiner in U. S. Patent Office, Art Illumination, 1607 East Capitol Street, Washington, D. C.

Ciampi, Guido, Electric Engineer, Compagnia Generale di Elettricita, Milan Italy, International General Electric Co., Schenectady, N. Y.

Doane, Leroy C., Engineer, Ivanhoe Regent Works of General Electric Co 5716 Euclid Avenue, Cleveland, Ohio.

Graves, Roy Martin, Testing Engineer, Commonwealth Edison Co., 28 North Market Street, Chicago, Ill.

Hail, Joseph C., Deputy Commissioner, Dept. of Gas and Electricity, City Hall, Chicago, Ill.

Herr, R. D., Interior Lighting Engineer, Westinghouse Electric & Mfg. Co., 1704 Union Bank Bldg., Pittsburgh, Pa.

Hillis, Arthur W., Lighting Specialist, Western Electric Co., Kirby & Dequindre Sts., Detroit, Mich.

Holland, E. J., Sales Manager, Consolidated Lamp and Glass Co., Coraopolis, Pa.

Holmes, Percy R., Engineer, National Lamp Works of G. E. Co., Nela Park. Cleveland, Ohio.

Olson, Melvin E., Salesman, National Lamp Works of G. E. Co., Buckeye Division, 1811 East 45th St., Cleveland, Ohio.

Plumb, Hylon T., Intermountain Engineer, General Electric Co., 720 Newhouse Bldg., Salt Lake City, Utah.

Rambusch, Harold, Rambusch Decorating Co., 2 West 45th St., New York, N. Y.

Rannenberg, K. S., Deputy Supt., Street Lighting Dept. of Streets & Engineering, Room 410, Municipal Bldg., Springfield, Mass.

Schumacher, Rudolph, Jr., Lighting Specialist, 960 Anderson Ave., Bronx, New York City.

Swackhamer, Robert J., Assistant Illuminating Engineer, General Electric Co., Schenectady, N. Y.

Weaver, K. S., Experimental Illuminating Engineer, Westinghouse Lamp Co., Clearfield Avenue, Bloomfield, N. J.

Williams, Harry E., Illuminating Dept., Empire Gas & Electric Co., 103 Castle Street, Geneva, N. Y.

Youtz, J. Paul, Electric Engineer, General Electric Co., Schenectady, N. Y.

Other Changes in Membership

One Associate Member Reinstated

Gleason, Homer E., Cascade Fixture Co., 1720 Yale Avenue, Seattle, Wash

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The General Secretary reported the death, on August 13, 1923, of one associate member, George V. Strahan, Mitchell Vance Co., Inc., 507 West 4th St., New York, N. Y.

CONFIRMATION OF APPOINTMENTS

As *Chairman of the Committee on Finance*—Adolph Hertz.

As *Chairman of the Committee on Papers*—A. L. Powell.

As *Chairman of the Committee on Editing and Publication*—Norman D. Macdonald.

As *Chairman of the Committee on Lighting Legislation*—Louis B. Marks.

As Chairman of the General Board of Examiners—Leonard J. Lewinson.

As Chairman of the Committee on Membership—G. Bertram Regar.

As Chairman of the Committee to Co-operate with Fixture Manufacturers—M. Luckiesh.

As Chairman of the Committee on Research—Ernest Fox Nichols.

As Chairman of the Committee on Progress—Francis E. Cady.

As Chairman of the Committee on Nomenclature and Standards—E. C. Crittenden.

As Chairman of the Committee on Motor Vehicle Lighting—Clayton H. Sharp.

At the meeting of the Council, October 11, 1923, the following were elected to membership:

One Member

PIERCE, ELMER S., Principal, Seneca Vocational School, 787 Seneca St., Buffalo, N. Y.

Five Associate Members

BERNHARD, LESTER S., Student, Ohio State University, 92 Chittenden Ave., Columbus, Ohio.

BOYD, GEORGE M., Westinghouse Elec. & Mfg. Co., George Cutter Works, South Bend, Indiana.

BULLER, C. S., Westinghouse Elec. & Mfg. Co., 426 Marietta St., Atlanta, Ga.

CHAPMAN, A. J., Electrical Development & Equipment Co., 180 West Lake St., Chicago, Illinois.

HOLT, THOMAS T., President, The Skybryte Co., 1100 Keith Bldg., Cleveland, Ohio.

CONFIRMATION OF APPOINTMENTS

As members of the Council Executive Committee:
Clarence L. Law, Chairman; Louis B. Marks, Samuel G. Hibben, Preston S. Millar and H. F. Wallace.

As members of the Committee on Finance:
H. F. Wallace and Frank R. Barnitz.

As members of the Committee on Papers:
R. W. Shenton, Vice-Chairman, Julius Daniels, George C. Cousins, N. D. Macdonald, H. H. Higbie, E. C. Crittenden, H. P. Gage, F. C. Taylor, J. L. Stair and R. H. Maurer.

As members of the General Board of Examiners:
G. Bertram Regar and H. V. Bozell.

As members of the Committee on Membership:
J. F. Anderson, C. A. Atherton, W. T. Blackwell, Frederick W. Bliss, R. D. Brown, James E. Buckley, W. E. Clement, George G. Cousins, E. C. Crittenden, J. Daniels, Henry D'Olier, Jr., J. Carl Fisher, H. W. Fuller,

H. E. Hobson, M. C. Huse, Karl E. Kilby, James D. Lee, Jr., F. W. Loomis, H. E. Mahan, Charles C. Munroe, John A. O'Rourke, S. L. E. Rose, H. H. Smith, J. L. Stair, L. A. S. Wood.

s *members of the Committee on Lighting Legislation:*
W. F. Little, W. T. Blackwell, F. C. Caldwell, George S. Crampton, H. B. Dates, E. Y. Davidson, Jr., J. E. Hannum, Ward Harrison, S. G. Hibben, J. E. Hoeveler, James E. Ives, M. G. Lloyd, M. Luckiesh, R. H. Maurer, A. S. McAllister, E. G. Perrot, W. J. Sherrill, R. E. Simpson, George H. Stickney, R. C. Taggart.

Chairman of the Committee on Sustaining Members: Herbert F. Wallace.

members of the Committee on Nomemclature and Standards:
Howard Lyon, Secretary, G. A. Hoadley, E. P. Hyde, A. E. Kennelly, M. Luckiesh, C. O. Mallioux, A. S. McAllister, E. C. McKinnie, C. H. Sharp, W. J. Serrill, G. H. Stickney.

Chairman of the Committee on New Sections and Chapters: D. McFarlan Moore.

Vice-Chairman of the Committee on Motor Vehicle Lighting: G. H. Stickney.

Secretary of the Committee on Motor Vehicle Lighting: W. F. Little.

Local Representatives:
G. O. Hodgson, Denver, Colo., Charles F. Scott, New Haven, Conn., J. Arnold Norcross, New Haven, Conn., R. E. Simpson, Hartford, Conn., R. B. Patterson, Washington, D. C., E. C. Crittenden, Washington, D. C., Charles A. Collier, Atlanta, Ga., W. R. Putnam, Boise, Idaho, H. B. Heyburn, Louisville, Ky., J. F. Murray, Springfield, Mass., Carl D. Knight, Worcester, Mass., Charles C. Monroe, Detroit, Mich., G. D. Shepardson, Minneapolis, Minn., Louis D. Moore, St. Louis, Mo., Frank C. Taylor, Rochester, N. Y., Harwood E. Mahan, Schenectady, N. Y., A. M. Wilson, Cincinnati, Ohio, W. E. Richards, Toledo, Ohio, F. H. Murphy, Portland, Oregon, F. A. Gallagher, Providence, R. I., J. M. Bryant, Austin, Texas, W. S. Rodman, Charlottesville, Va., Fred A. Osborn, Seattle, Wash., F. A. Vaughn, Milwaukee, Wis., L. V. Webber, Montreal, Canada.

Official Representatives to other Organizations:

e United States National Committee of the International Commission on Illumination—Louis B. Marks and Preston S. Miller.

erican Institute of Electrical Engineers Standards Committee—Clayton H. Sharp.

erning Board of the American Association for the Advancement of Science—Ernest F. Nichols and Clayton H. Sharp.

visory Committee, Engineering Division, National Research Council—Dugald C. Jackson.

E. S. C. Sectional Committee, Building Exits Code—R. E. Simpson.

w York State Committee on Places of Public Assembly—George H. Stickney.

CHARLES PROTEUS STEINMETZ

By E. W. Rice, Jr.

The sudden death of Doctor Steinmetz comes as a great shock to his friends in the General Electric organization, including the directors, officers and every employe. He joined our ranks some thirty years ago and during all this time has rendered services of the most conspicuous character and extraordinary value. He had a world wide reputation as a scientist, electrical engineer, author and teacher. He was as well known in Europe, South America, Africa, Australia and the Orient as here in his adopted America. Universally acknowledged as one of the world's greatest scientists, he was, if possible, a greater teacher. He was the author of many scientific papers and of a large number of electrical books which have long been the accepted standard text books in colleges, laboratories and workshops everywhere. He possessed marvelous insight into all scientific phenomena and unequalled ability to explain in simple language the most difficult and abstruse problems. Countless electrical engineers now occupying positions of great importance in our Company and elsewhere in the world, will gladly give testimony of their debt to him. All those who knew him mourn the loss not only of a great teacher and an inspiring personality, but of a cheerful and ever helpful friend.

THE DEATH OF DR. STEINMETZ

Charles P. Steinmetz, A. M. Ph. D., chief consulting engineer of the General Electric Company, and one of the world's most famous engineers, died suddenly at his home in Schenectady, N. Y., October 26, from acute dilatation of the heart following chronic myocarditis, a weakening of the heart muscles, of many years standing.

Dr. Steinmetz left Schenectady the first of September intending to take a rest. He wanted to see the Pacific Coast, which he had never visited. Word of his trip sped ahead of him, and requests that he speak at various places immediately resulted. His speaking arrangements were carefully made, but so many wished to hear him that in trying to comply he overtaxed himself. That this was the cause of his death is not certain, however, owing to the nature of his malady.

He returned home September 13th and, an examination by his physician disclosing the fact that his heart action was unsteady, a complete rest was advised. During the first part of the week in which he died, his condition seemed to be improving. He had been about the house and on Thursday night declared he was beginning to feel like himself again. The night before he died he was dressed and passed the evening in his library, discussing with his adopted son, J. LeRoy Hayden, and some friends, a scientific book, "The Physics of the Air." He was bright and cheerful and remarked that he would soon be out again and at work. He retired about 10:30, and awoke the following morning in the best of spirits. He walked up and down the hall and announced to the nurse that he was ready for breakfast. Mr. Hayden was with him for a few minutes, chatting, before he went down to his own breakfast. As Mr. Hayden

Charles P. Steinmetz
1865-1923

ıt down stairs, he passed his son, "Billy" Hayden, who was on his way up-rs with Dr. Steinmetz's breakfast. Calling to the latter, young Hayden ɛived no response, and immediately summoned his father. Physicians ried to the Steinmetz home, but he was dead.

Word was immediately sent to the General Electric Works and the news ɛad throughout the city, causing great sorrow, for, in addition to their ııration for his scientific attainments, his fellow citizens held him in high sonal esteem. Flags at the General Electric Works and in the city were -masted, the latter by order of the acting mayor.

Charles Proteus Steinmetz was born April 9, 1865, at Breslau, Germany.

Educated at the gymnasium (high school) and then at the University of slau, where he studied mathematics and astronomy, then physics and mistry, and finally, for a short time, medicine and national economy.

Involved in the social democratic agitation against the government, he ped to Switzerland in 1888, and there studied mechanical engineering at Polytechnisum.

In 1889 he immigrated to America, and found a position with the Osterheld ichemeyer Manufacturing Company, first as draftsman, then as electrical ineer and designer, and finally on research work in charge of the Eichemeyer oratory, in New York.

With the absorption of the Eickemeyer-Field interest by the General ɛtric Company, Dr. Steinmetz joined the latter, was attached to Mr. F. Parshall's calculating department in Lynn, Mass. With the transfer of company's headquarters to Schenectady in the spring of 1894, Dr. Stein-z organized and took charge of the calculation and design of the Company's aratus and of the research and development work.

For a number of years Dr. Steinmetz was Professor of Electrical Engineering Union College, and at the present time is Professor of Electro-Physics at on University, at the same time retaining his connection with the General tric Company as chief consulting engineer, and about the year 1910 again red into closer relation with this company by organizing a consulting neering department under his charge.

Some of the more important of his publications and articles are:

A series of mathematical papers on Polydimentional involutory correspond-.

A series of investigations on the magnetic circuit and the law of hysteresis.

A series of investigations on dielectric and electrostatic phenomena.

A series of papers on "The Design and Performance of Electrical Apparatus," as transformers, induction machines, synchronous machines, commutat-machines, etc."

A series of papers on "High Frequency Oscillations and Surges in Electric uits."

A series of papers on "Radiation, Light and Illumination,"

A series of papers on "Mechanical Thormodynamics and Steam Turbines."

Most of his papers on electrical subjects are published in the TRANSAC-s of the A. E. E. E.

The following books have been published by Dr. Steinmetz: A popul work on "Astronomy and Meteorology," in the German Language, 1st editi 1889.

"Theory and Calculation of Alternating Current Phenomena," 1st editi 1897, 5th edition 1916.

"Theoretical Elements of Electrical Engineering," 1st, edition 1901, 4 edition 1916.

"General Lectures on Electrical Engineering," 1st edition 1908, 5th editi 1911.

"Theory and Calculation of Transient Electric Phenomena and Oscill tions," 1909, 3rd edition 1919.

"Radiation, Light and Illumination," 1st edition 1911, 2nd edition 191

"Electric Discharges, Waves and Impulses, "1st edition 1911, end editi 1914.

"Electrical Engineering Mathematics," 1st edition 1911, 2nd edition 191

"Theory and Calculation of Electric Circuits," 1917.

"Theory and Calculation of Electrical Apparatus," 1917.

In 1902, Dr. Steinmetz received the honorary A.M. degree from Harva University, 1903 the honorary Ph.D. degree from Union College.

Dr. Steinmetz is Past-President of the National Association of Corporati Schools, Vice-President of the International Association of Municipal Elect cians, Past-President of the American Institute of Electrical Engineers, hono ary member of the National Electric Light Association, Past-President of t Illuminating Engineering Society, fellow of the American Association for t Advancement of Science, member of the (British) Institution of Electri Engineers, member of the American Mathematical Society, the Quaterni Society, the Society of Mechanical Engineers, the Electrochemical Socie the Illuminating Engineering Society, and the Physical Society.

He was a President of the Common Council and twice President of t Board of Education of the City of Schenectady.

NEWS ITEMS

SECTIONAL COMMITTEE ON CODE OF LIGHTING FOR SCHO BUILDINGS

Sponsors: Illuminating Engineering Society and American Institute Architects. Chairman: L. B. Marks, 103 Park Avenue, New York, N. Secretary: W. F. Little, Electrical Testing Laboratories, 80th Street and E End Avenue, New York, N. Y. American Gas Assn.—R. H. Maurer; Ame can Institute of Architects—James O. Betelle, C. E. Dobbin, and S. W. Jon American Institue of Electrical Engineers—C. E. Clewell, American Medi Assn. (Ophthalmological Section) Dr. Geo. S. Crampton; American Pub Health Association—Dr. R. W. Elliott; American School Hygiene Assn Dr. T. D. Wood; American Society of Safety Engineers—Wm. Darlingt

Eye Sight Conservation Council of America—J. E. Hannum; Illuminating Engineering Society—W. F. Little, L. B. Marks, and M. Luckiesh; National Association Public School Business Officials—James J. Maher; National Bureau of Casualty & Surety Underwriters—Thomas M. Nial; National Committee for the Prevention of Blindness—Mrs. Winifred Hathaway; National Council of Schoolhouse Construction—Hubert Eicher; National Education Association—Frank I. Cooper; National Electric Light Association—Ward Harrison; National Safety Council—G. H. Stickney; U. S. Bureau of Education—Dr. Wm. T. Bawden; U. S. Bureau of Standards—Dr. M. G. Lloyd; U. S. Public Health Service—Dr. Taliaferro Clark; Women's Bureau of the U. S. Department of Labor—Miss Mary N. Winslow.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS

AN INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illuminating engineering and allied subjects. This index is arranged alphabetically according to the names of the reference publications. The references are then given in order of the date of publication. Important references not appearing herein should be called to the attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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1923-1924

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OF THE ILLUMINATING ENGINEERING SOCIETY

"......the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto"

Featuring

1923 Convention Papers

Hospital Operating Room Lighting with Reproduced Daylight

By Norman Macbeth

VOL. XVIII. NOVEMBER, 1923 NO. 9

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OF THE
ILLUMINATING ENGINEERING SOCIETY

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TRANSACTIONS
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VOL. XVIII　　NOVEMBER, 1923　　NO. 9

Are Present Standards of Industrial Lighting Efficient?

IT IS TRUE that any illuminating engineer can point out several lighting installations in factories where the illumination can be fairly said to be not only well planned but adequate, according to our present judgment. Nevertheless taking plant by plant and judging each plant as a whole rather than by the best in each plant, it becomes apparent that there is much to be done before lighting can be called satisfactory. In the same factory or in adjoining buildings there usually can be found one or several miserable examples for ready contrast.

The physical laws governing light and illumination were quite adequately set down many years ago. It must be confessed, however, that in spite of dozens of volumes and hundreds of articles in the technical press, the practical application of the principles of vision, such as the effect of different qualities and quantities of illumination upon sight and upon the comfort and health and sustained efficiency in production have not been so clearly understood or emphasized even by those engaged in the sale of lamps and lighting equipment.

In recent years the scientific group have seemed to have taken an increased interest in the practical problems of lighting, and we have seen as a result papers from them in the TRANSACTIONS of the Society with a special usefulness from the view point of practice. Then the practical experimenters in shops have been applying a greater care in their studies of the effects of different systems of

lighting under conditions of actual production. There is becoming available, therefore, an increasing fund of solid information as against speculation and snap judgment to guide practice.

And it would seem that the most important facts that have been developed are of apparently a rather simple and obvious character.

For instance, it is not hard to believe and seems to be substantiated, that for all around purposes, industrial illumination roughly approximating natural daylight in color combines the largest advantages in quickness and accuracy of sight and sustained comfortable vision, while conducing to a cheerful atmosphere. Other colors have advantages for special purposes no doubt, but an error seems to have been often made in applying the results of special experiments to the broadest run of conditions.

Next, light to man is a great deal like air—there can hardly be too much of it unless applied in a violent or unnatural manner. There has been so much of confusion of *glare* with *quantity* of illumination, many have observed bare glaring lamps and have concluded that the quantity of light must be kept low to avoid discomfort or even injury. Practically it appears that there is no limit other than cost to the quantity of light that is useful in industry.

It is to be noted that with higher levels a certain amount of care to diffuse the light reasonably becomes the more essential. But also where the higher levels can be obtained less need is felt for special arrangements of the lighting equipment.

Predictions are venturesome but there seems good reason to believe that in the next decade installations providing well diffused illumination of the order of 25 or 30 foot-candles will become as common as 10 foot-candles are today. No illumination production efficiency tests yet conducted have been carried to a level so high that the added cost of light has overbalanced the gain in production efficiency. Is this not something for thought?

EARL A. ANDERSON

REFLECTIONS

When Daylight Costs More Than Artificial Light

IN IMAGINATION one needs to look backward only a century to reach a period of inadequate artificial light from candles and other feeble flames, when light cost fifty times more than it does now. During that century development gradually gained momentum until within the last score of years the possibilities of artificial light have increased so rapidly that the general public has not been able to keep pace with them. Proper and adequate lighting is just as essential to human progress as clean and sufficient air. The public has a pretty full appreciation of the hygienic value of fresh air. The airtight bedchambers of a century ago have given way to ventilated rooms, but the old attitude toward lighting— a most natural inheritance of centuries of costly and inadequate artificial light—persists far too tenaciously. This attitude cannot be changed too soon in the interests of greater production, greater safety, greater efficiency and greater progress. Human eyes are the product of countless centuries of adaptation to daylight intensities which are more than a thousand times greater than artificial lighting intensities generally but erroneously considered sufficient. The psycho-physiological laws of vision are proof of this, and they are well supported by the results from installations of good lighting.

There is another interesting argument to be derived from recently published investigations (by M. Luckiesh and L. L. Holladay) on the cost of daylight. Daylight is free outdoors when it is available at all. By coming indoors mankind created conditions which not only decreased the intensity available for indoor activities but removed daylight from the free list. These investigations have shown that by charging to daylight the additional cost of window and skylights, their maintenance, the additional heat losses, etc., natural lighting costs as much as and in many cases more than good artificial lighting. Owing to the growing complexity of our econom-

ic life such investigations cannot be ignored. The results are bound to have their influence on building in congested districts and perhaps on others.

However, without entering into a discussion of the economic phases, the central-station company and others interested in lighting progress should find much use for the knowledge that daylight indoors costs as much as artificial lighting. In order that the people shall enjoy proper and adequate lighting they must be relieved of the inhibiting attitude that artificial light is costly. That it is a very inexpensive necessity, or that its cost is insignificant as compared with its benefits, can be proved by actual data. But oftentimes an indirect argument is more effective. The simple statement that daylight in homes, offices and factories costs as much as proper and adequate artificial lighting, and sometimes more, is startling, true and convincing—three excellent characteristics for statements made for an educational purpose—*Editorial, Electrical World, Nov. 3, 1923.*

Incandescent Lamps Forty-four Years Old

THE incandescent electric lamp has just celebrated its 44th birthday. On October 21, 1879, the first carbon filament lamp was perfected by Edison in his little Menlo Park laboratory, but three years later, when the first electric central station in the world was started in New York City, there were not enough electric lamps in the world to light a modern office building.

In 1881, when the commercial manufacture of lamps was begun, 30,000 were produced. Last year the total, for the United States alone, was more than 500 million.

Research, experiment and improved manufacturing methods have worked, with decreasing prices of current, to bring the cost of electric light to the consumer to a point lower than it has ever been before.

With the use of tungsten filaments in 1907, there began an improvement in electric lamps that has continued, until the 40-watt lamp of to-day is more than eight times as efficient as the 40-watt lamp of 1907. In 1922 approximately $500,000,000 were spent for electric light. To produce the same amount of light in 1880 would have cost $3,500,000,000.

PAPERS

THE RELATION OF ILLUMINATION TO PRODUCTION*

BY D. P. HESS** and WARD HARRISON***

SYNOPSIS: This paper is a report of extensive tests on the time required for the inspection of parts of roller bearings under various levels of illumination from 5 to 20 foot-candles. Over 7,000,000 separate pieces of material were inspected during the test period. The types of lighting employed as well as the illumination levels were found to have an important bearing on the output of the department. Cost data on the lighting and the value of increased production are included in the paper.

OBJECT

This test was conducted in an effort to establish what relationship, if any, exists between illumination and production in a roller bearing plant.

DESCRIPTION OF TEST DEPARTMENT

About fifteen per cent of all those employed in the plant are inspectors and the section chosen for the test was known as the Green Inspection Department. The nature of the work in this Department consisted of inspecting the material in the green, i.e. just as it was turned out by the automatic screw machines and before heat treating. The material inspected as illustrated in Figure 1 consisted of various sizes of cups, cones and threaded cones, which are separate parts of a roller bearing.

The work is carried on in three stages, the first group of inspectors gauge the material for diameter and depth, the second inspect for defects such as chatter, tool marks, ingot breaks, thin ribs, and bad champfer, and the third group for imperfections in the thread on the inside of the cones, bad mill, bad champfer, and inadequate burnishing. Some of the work such as the inspection of threaded

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cones, ingot breaks and chatter marks require close visual inspection, while in some of the gauging, which is done by means of indicating and limit gauges, as illustrated in Figure 2 and 3, relatively little is required of the eyes.

The personnel of this Department at the time the test was begun consisted of a foreman, clerk, and 38 inspectors. This number varied each week, the average number of inspectors during the test being forty-four. Table I shows the weekly change in personnel of the Department during the entire test.

TABLE I.

	Feb. *15–21*	Feb. *22–28*	Mar. *1–7*	Mar. *8–14*	Mar. *15–21*	Mar. *22–28*	Mar. *29–Apr. 4*	Apr. *5–11*	Apr. *12–18*	Apr. *19–25*
Total Inspectors	38	48	43	43	41	45	45	46	48	43
New Inspectors Hired	8	12	7	7	1	6	5	4	6	1
Inspectors' Services Discontinued	2	12	7	3	2	5	3	4	6	6

LIGHTING SYSTEM

The area occupied by the Green Inspection Department has dimensions of approximately 30 by 60 feet and is located near one corner of a large one story building covering about 6 acres. Figure 4.

The lighting system in this Department at the beginning of the test consisted of six outlets, four of which were equipped with 200-watt clear lamps, and two with 150-watt clear lamps. The six lamps were equipped with enameled-steel reflectors and gave an average illumination of about 2 foot-candles. The distribution of light, however, due to wide and irregular spacing of the units, was uneven and caused bad shadows. Figure 5 shows the lighting effect produced by this system.

The Department is so located that it receives daylight from windows at a distance on one side and from skylights located in the saw tooth roof construction. During the greater portion of the time during the first two weeks of the test, the above mentioned lighting system was used as a supplement to the natural daylight. The resulting average illumination in the test section for this period was approximately 5 foot-candles.

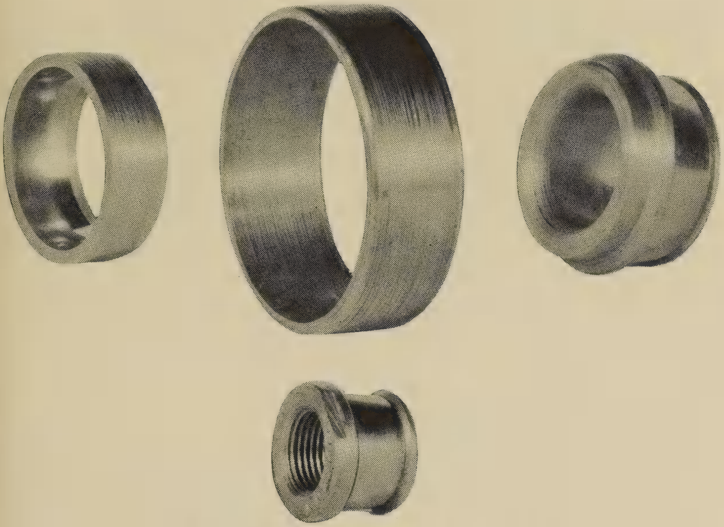

FIG. 1.—Various Types of Material Inspected

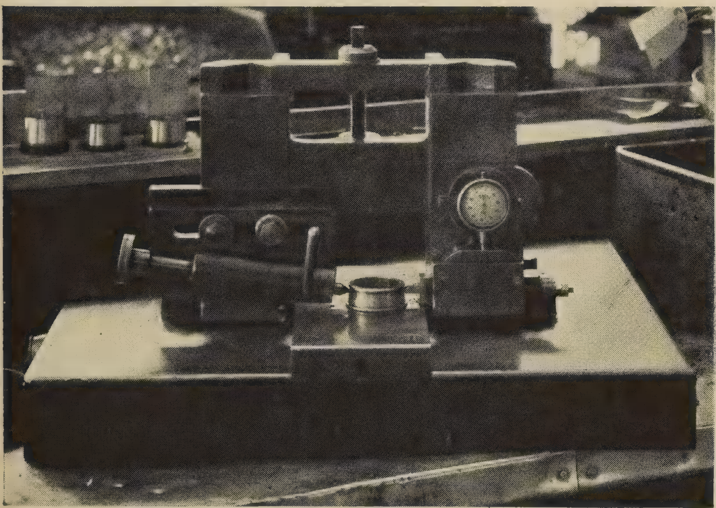

FIG. 2.—Indicating Gauge

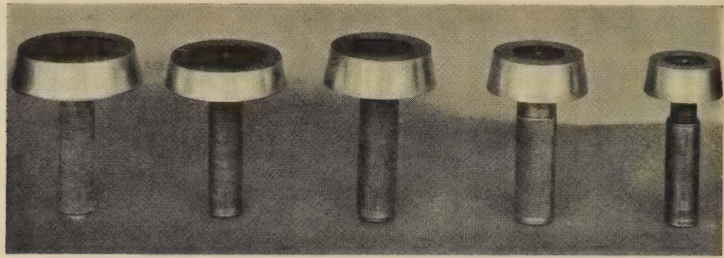

Fig. 3.—Taper Gauges

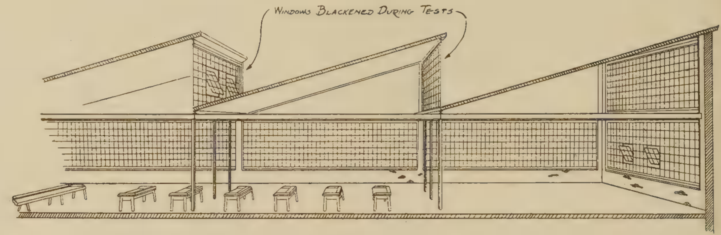

Fig. 4.—Sectional View of Green Inspection Department

Fig. 5.—Original Lighting System in Green Inspection Department

The new lighting system, Figure 6, consisted of 28 Glassteel Diffusers located on 8 by 10 foot-centers and mounted 12 feet from the floor. This type of lighting unit, Figure 7, has an enclosing globe that entirely surrounds the lamp producing an even distribution of light with soft shadows, and a noticeable absence of objectionable specular reflection. The lighting effect obtained by the above mentioned system is shown in Figure 8.

In an effort to maintain the levels of illumination as uniform as possible under this system, the skylights in the saw-tooth roof were blackened.

PROCEDURE

The test was planned to include investigations of the old system, a 6 foot-candle system, a 13 foot-candle system, and a 20 foot-candle system. The test weeks in each case were begun on a Thursday and ended on a Wednesday, continuing for a period of ten weeks. Due to the advancing season and much stronger daylight it was found impossible to return to the original 5 foot-candle system obtained from the unobstructed skylight and 6 incandescent lamps. Table II gives the order of tests.

TABLE II.

Week	Old Lighting *5.0 Foot-Candles*	New Lighting *6.0 Foot-Candles*	New Lighting *13.0 Foot-Candles*	New Lighting *20.0 Foot-Candles*
Feb. 15-21	x			
Feb. 22-28	x			
Mar. 1-7				x
Mar. 8-14			x	
Mar. 15-21		x		
Mar. 22-28			x	
Mar. 29-Apr. 4				x
Apr. 5-11		x		
Apr. 12-18				x
Apr. 19-25			x	

Records were available in the Green Inspection Department which showed the number of pieces inspected per day with the total number of actual inspection hours. Often, especially in the case of overtime, an inspector is called upon to do general work in the department, such as moving containers and cleaning up. In that event, his time is not shown on the inspectors' records, but only on the time cards. If an experienced inspector is requested to

instruct a new worker, the experienced inspector's time does not appear in the inspection records. All employees in this Department are paid on an hourly basis.

The question has often been raised as to whether atmospheric conditions materially affect the output of factory workers. In an effort to obtain data on this point wet and dry bulb thermometer readings were taken four times a day at the test area and from these the relative humidity calculated. The daily weather bureau record showing the per cent sunshine, exterior temperature, and amount of precipitation was also tabulated.

RESULTS

Table III and Figure 9 show the per cent of sunshine, average weekly relative humidity and average weekly interior temperature. It will be noted that the tests were run at a season of the year when artificial heat was necessary and as a result both the interior temperature and the humidity were fairly constant. There was a considerable variation in per cent of sunshine for the several weeks but the variation apparently did not influence the production.

TABLE III.

Week	Percent *Sunshine*	Relative *Humidity*	Interior *Temperature*
Feb. 15-21	63.0	—	—
Feb. 22-28	22.0	—	—
Mar. 1-7	61.0	66.4	74.8
Mar. 8-14	69.0	63.8	72.0
Mar. 15-21	58.c	66.5	71.0
Mar. 22-28	47.0	68.6	72.3
Mar. 29-Apr. 4	62.0	71.0	71.6
Apr. 5-11	76.0	70.3	72.0
Apr. 12-18	52.0	68.3	72.4
Apr. 19-25	90.0	65.5	72.7

Table IV shows the total number of pieces inspected and the number of actual inspection hours for the Department during each of the ten weeks of the test. The total number of pieces inspected was 7,313,323.

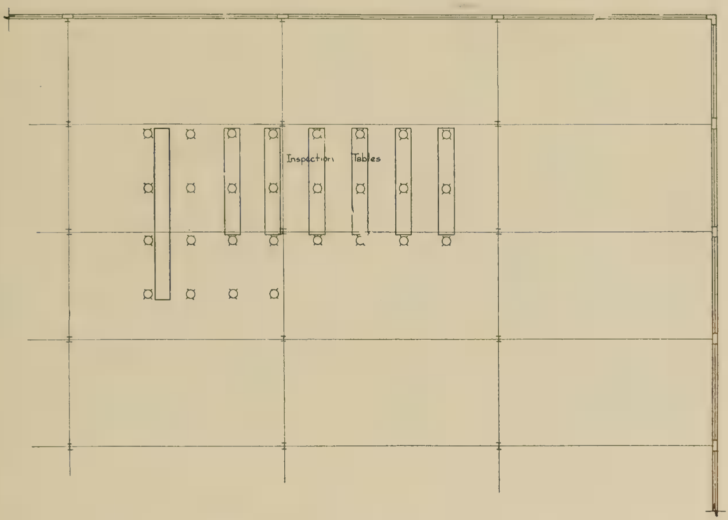

FIG. 6.—— Outlet for a Mazda C lamp fitted with a Glassteel Diffuser located 12 feet above the floor.

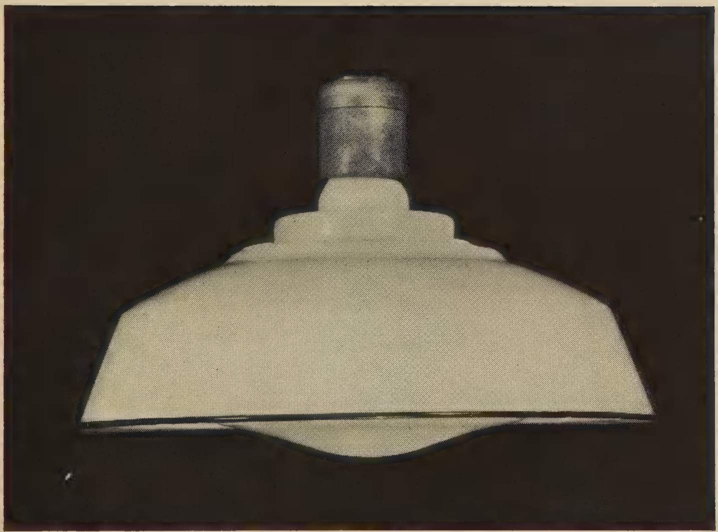

FIG. 7.—Glassteel Diffuser

Fig. 8.—New Lighting System in Green Inspection Department

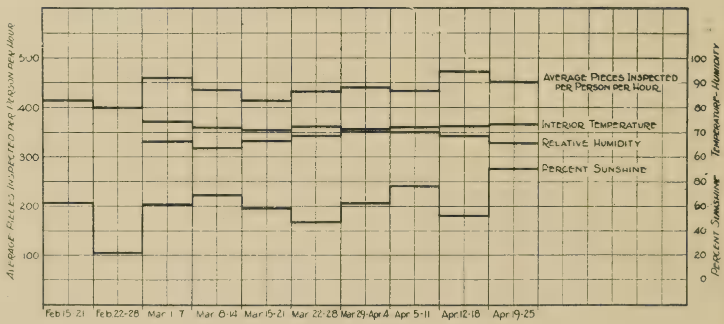

Fig. 9.

TABLE IV.

Foot-Candles		Total Pieces Inspected	Total Inspection Hours	Average Pieces Inspected per Person per Hour
5.0	(Old System)	684,164	1,644	415
5.0	"	581,709	1,449	400
20.0	(New System)	681,621	1,476	462
12.8	"	708,559	1,620	437
5.7	"	739,627	1,778	415
11.9	"	735,316	1,698	432
20.2	"	763,762	1,737	440
6.2	"	809,631	1,866	434
20.2	"	842,138	1,783	472
13.5	"	766,796	1,700	451

Table V shows the average of all weeks under the same lighting system with the percentage increase in production.

TABLE V.

Foot-Candles	Average Pieces Inspected per Person per Hour	Increase
20.0	458	12.5%
13.0	440	8.0%
6.0	424	4.0%
5.0 (Old System)	407	0.0%

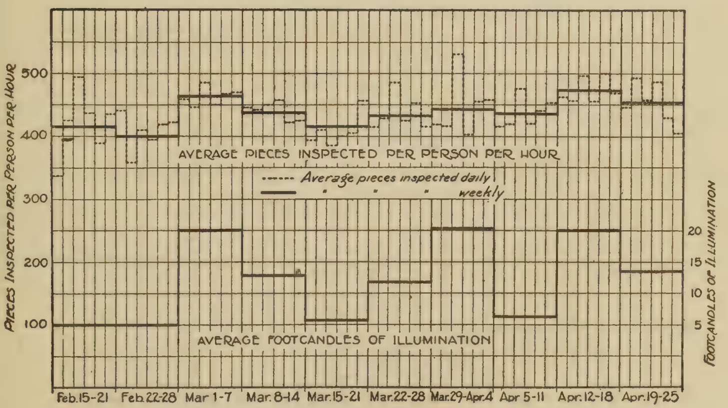

FIG. 10.

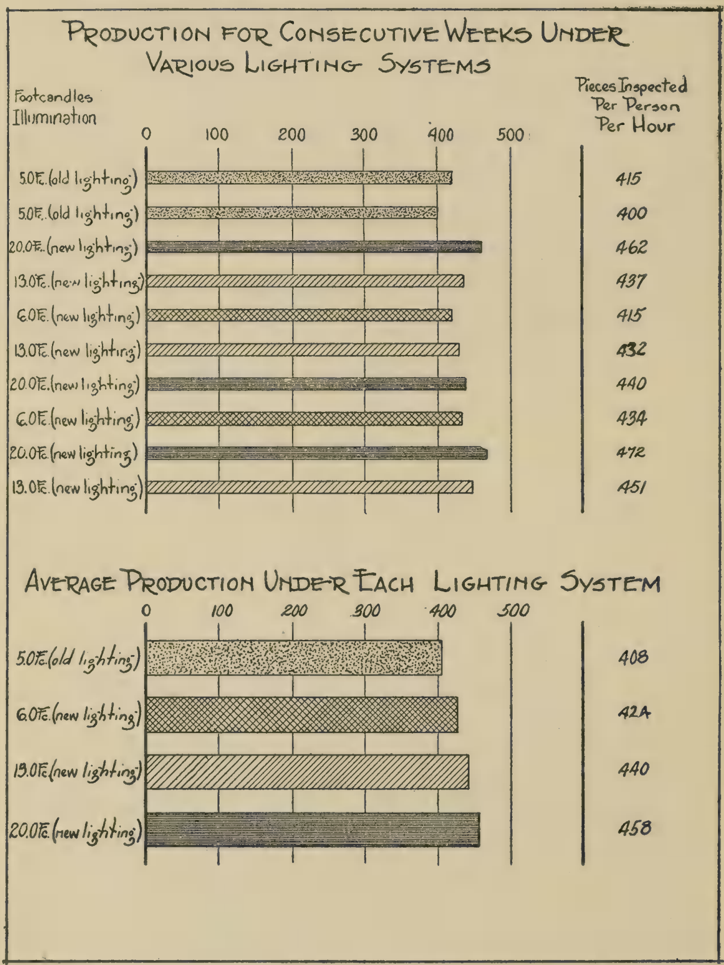
PRODUCTION FOR CONSECUTIVE WEEKS UNDER VARIOUS LIGHTING SYSTEMS
Footcandles Illumination
Pieces Inspected Per Person Per Hour
0
100
200
300
400
500
5.0 Fc. (old lighting) 415
5.0 Fc. (old lighting) 400
20.0 Fc. (new lighting) 462
13.0 Fc. (new lighting) 437
6.0 Fc. (new lighting) 415
13.0 Fc. (new lighting) 432
20.0 Fc. (new lighting) 440
6.0 Fc. (new lighting) 434
20.0 Fc. (new lighting) 472
13.0 Fc. (new lighting) 451
AVERAGE PRODUCTION UNDER EACH LIGHTING SYSTEM
0
100
200
300
400
500
5.0 Fc. (old lighting) 408
6.0 Fc. (new lighting) 424
13.0 Fc. (new lighting) 440
20.0 Fc. (new lighting) 458

FIG. 11.

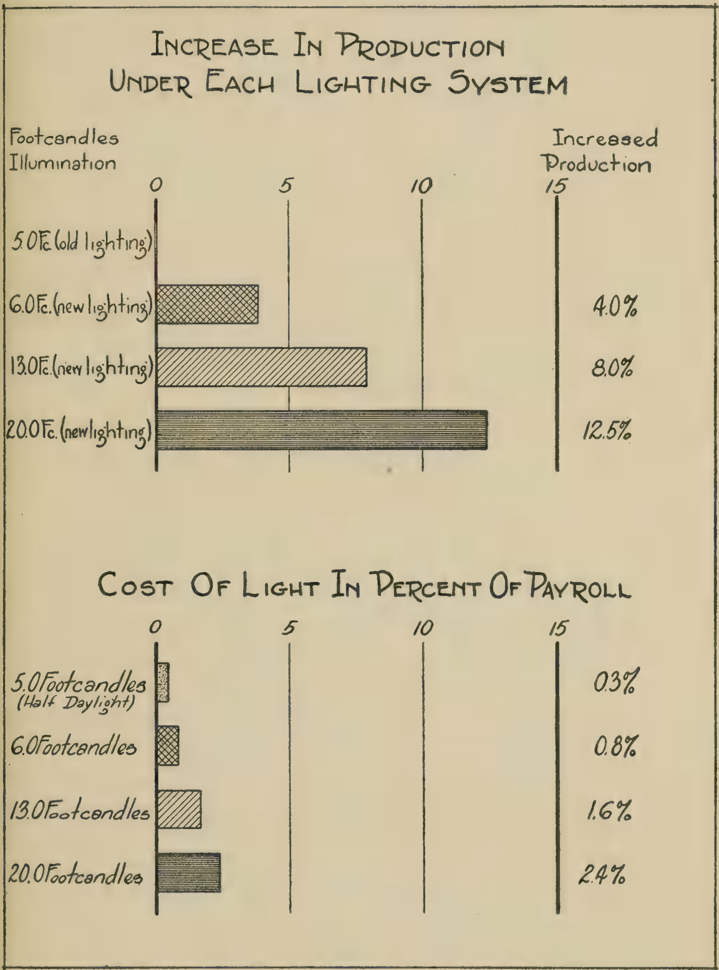
INCREASE IN PRODUCTION
UNDER EACH LIGHTING SYSTEM
Footcandles
Illumination
Increased
Production
0
5
10
15
5.0Fc.(old lighting)
6.0Fc.(new lighting)
4.0%
13.0Fc.(new lighting)
8.0%
20.0Fc.(new lighting)
12.5%
COST OF LIGHT IN PERCENT OF PAYROLL
0
5
10
15
5.0 Footcandles
(Half Daylight)
0.3%
6.0 Footcandles
0.8%
13.0 Footcandles
1.6%
20.0 Footcandles
2.4%

FIG. 12.

These results are also shown graphically on Figures 10, 11 and 12. Figure 10 also shows the daily rate of production for the entire period. The tests furnish apparently conclusive proof that for the class of work carried on in the Green Inspection Department the production is materially affected by the character of illumination supplied. It will be noted that a well designed system of illumination, giving approximately 6 foot-candles with a minimum of glare and objectionable specular reflection, results in an increase of 4 per cent in production over that obtained under a faulty system which gave about the same average foot-candles. Likewise, an increase in illumination from 6 foot-candles to 13 foot-candles with a well designed system results in a further 4 per cent increase in production. Increasing the illumination from 13 foot-candles to 20 foot-candles results in an additional 4.5 per cent increase, or comparing the 20 foot-candle system with the one originally in use a 12.5 per cent increase in production is found.

ECONOMICS

The current consumed with the 20 foot-candle system amounts to 8.4 kilowatts which at a rate of $0.03 per kilowatt hour results in a cost of $0.25 per hour for current to which should be added approximately $0.07 for lamp renewals and other charges making a total cost of $0.32 per hour. With the old 5 foot-candle lighting system about half of which was daylight, the cost for current and lamp renewals was $0.04 per hour. The inspectors receive an average wage rate of approximately $0.30 per hour or for 44 people a total of $13.20 per hour. A 12.5 per cent in production means, therefore, a saving of $1.47 per hour in labor which is five times the added cost of the lighting. To put the matter in another way, the new lighting increased the production 12.5 per cent at a cost of less than 2.5 per cent of the payroll.

The authors desire to express their appreciation of the valuable services rendered by Mr. C. M. Snyder in the conduct of the tests which have been described.

DISCUSSION

GEORGE AINSWORTH: Might I ask if the inspectors knew at about which level the illumination was maintained during the different periods of inspection, if they knew whether they were working under, say, a quarter or a half or twice as much light? Or were they kept in ignorance of these changes?

C. M. Snyder: The inspectors did not know a test was being conducted. They, of course, could tell the illumination was lower, but they did not know that the lamp sizes were actually being changed. Some of them were under the impression that the lighting equipment was being tested, and a few thought that the lamps were being dimmed and made brighter by means of rheostats.

Julius Daniels: I would like to ask the speaker which system they decided to install.

C. M. Snyder: The 20 foot-candle system is installed at present.

Charles Gallo: I would like to ask when inspecting tool-marks, thin ribs, etc., whether there was any advantage in using that steel-glass diffuser over bowl enameled Mazda C lamps.

It would seem that too much diffused light, for examining such tool-marks, would tend to obliterate the tool-mark instead of making it more prominent, and in that way hinder fast inspection; and, that if there were more directed light, that is, not so great a diffusion, more rapid inspection could possibly be obtained.

C. M. Snyder: We found that the Glassteel Diffuser gave a very satisfactory illumination for this type of work. If the light is so bright that specular reflection results, it is impossible for the inspectors to see the tool marks or other imperfections due to the amount of light that is thrown back from the material into their eyes. The Glassteel Diffuser gives a very soft, diffused light and still shows up these imperfections very plainly.

Thomas G. Ward: I would like to ask Mr. Snyder if the worth of the production—the increase in production—was figured in comparison, instead of the wage per hour. The $1.47 per hour saving is a very minor consideration in comparison to the increase in production—the worth of the increase in production.

C. M. Snyder: I do not believe I understand your question.

Thomas G. Ward: You get above a standard cost on production. Is the increase in production worth more than the comparison between the saving of labor and the cost of light?

C. M. Snyder: This is figured on the average wage rate of the inspectors per hour.

C. A. Atherton: I assume from the figures that the employees in the portion of the factory tested are all day or hour workers. I wonder if similar tests have ever been conducted in factories in

which piece-workers are employed. In this case, there would be the added incentive to work as fast as possible independent of the illumination. I wonder whether the same general order of increase in work accomplished might be expected from increased illumination under conditions in which the workers already had an incentive to work as fast as possible."

C. M. Snyder: There have been various tests of that description including piece workers and the regular scale. Although there was some overtime taken into consideration here, the results are calculated on an hourly basis.

Davis H. Tuck: Mr. Gallo brought up a point a minute ago that I had in mind to bring up and that is the specular from such pieces as this one (indicating) and this one (indicating). Under diffused lighting, you can't pick out imperfections on such specular surfaces as you could if you had some specular reflection, and I believe that in Classes 2 and 3 perhaps the increase in production could be further raised if they had specular reflection.

Furthermore, I think in Table IV on Page 791 if the amount of rejects had been tabulated, it would tend to increase the production shown, because if you pick out some bad pieces you look at them a little longer before you throw them away, and under good illumination there would be more rejects. In such a case, there would be more rejects and I think the increase in production would be a good deal higher than twelve and a half per cent.

G. H. Stickney: In connection with this question of lighting specular surfaces for inspection, my experience indicates strongly in favor of diffusing light sources. It is, of course, impracticable to illuminate such a surface. If, however, a light source of low, uniform brilliancy is reflected by the surface, scratches, cracks and distortions show up quite conspicuously.

It is a well established practice, for inspectors use the reflection of the sky in this way, and a lamp with proper diffusing equipment can easily be made to act as a miniature sky. If a lamp filament or other source of uneven brilliancy is so reflected, the contrasts conceal the irregularities of the surface.

I have verified this experience in the inspection of glossy discs for electric meters, rollers for bearings, glass, glossy rubber, etc. In the roller bearing factory, they had experimented for several

months with exposed filament equipments, without any success. The diffused light scheme at one-fourth the wattage, worked from the start.

It is, of course, necessary to have the position of the lamp with regard to the operator and work such as to facilitate reflection to the eyes of the operator, that is, the lamp should be above and beyond the work.

J. C. FISHER: If I understood Mr. Snyder correctly, the skylight was blackened during the test and artificial light used entirely. Whether or not that is true I would like to know what the estimated increase in production would be if the daylight were used as far as possible and simply supplemented with the artificial lighting. In other words, I presume the artificial lighting would be used only a part of the total time and therefore there would be quite a fall-off in that percentage increase in production due solely to the artificial light.

I would like to know approximately what that would amount to, because that is a question often raised by people who have a so-called daylight factory in which they object to spending a great deal for an increased lighting installation on that ground.

C. M. SNYDER: Figure 4 shows that a considerable amount of actual daylight was present on the inspection tables from the wall windows, although the skylights were blackened during the test.

I think you will find that the season of the year makes a great deal of difference in the amount of daylight present. This test was run during the winter months, therefore, the percent of sunshine was appreciably lower.

I regret to say that I do not have any exact figures available at the present time as to the percentage increase or decrease that there would be if daylight were used in conjunction with the artificial light.

WARD HARRISON: There are one or two sidelights on this test which are also quite interesting. First, we tried to determine, if possible, if outside conditions such as sunshine, or the lack of it, high temperatures or low temperatures, had anything to do with how much the operator felt like working, or how much they accom-

plished. It seems to be definitely established, as far as this test is concerned, that such outside conditions had no appreciable effect upon production.

One reason that the enclosing fixtures were chosen as a standard for this test was that the size of lamp could be changed without the operators necessarily being aware of it. They knew that some test on fixtures was being conducted, but few, if any of them, suspected that the amount of work which they turned out was the factor to be determined. Incidentally they did complain bitterly when the illumination was reduced to 6 foot-candles, although they had been able to get along fairly well before under the old, 5 foot-candle system.

Mr Ward brought out the point that direct labor is only one of the items in factory production which may be affected by the lighting; another is the quality of the product turned out. We could scarcely get any figures on this, however, from the department under test, since their job is looking for defects in the work of others; if they reject 2.4 per cent one day and 1.7 per cent the next, it is impossible to tell whether the high rejections in the first case is due to their ability to see better or that a more defective product was being inspected.

As to the amount of daylight; in February every bit of available light was utilized, that is, all the old artificial lighting was turned on and all the daylight they could get was allowed to enter, yet the sum of the two averaged throughout the day was only 5 foot-candles. Accordingly the Timken Roller Bearing Co., was interested particularly in securing a lighting system which would carry them through the winter months of December, January, and February,—when the daylight itself does not average more than three or four foot-candles.

James E. Ives: (Communicated) This paper is an important contribution to the problem of the relation of production to illumination. Although this subject is of the greatest interest to business men and engineers, very little definite information on it exists at the present time.

The office of the Industrial Hygiene and Sanitation of the U. S. Public Health Service is particularly interesting in this paper on account of the investigation recently carried on by it on the same problem, in the New York City Hall Post Office. We found a

marked increase in speed of working, among the letter separators, when the illumination was raised from 2.8, successively, to 3.6, 8.0 and 14.0 foot-candles. The workers used in the test were divided into three groups, according as their vision *without glasses* was good, medium or poor. The percentage increase in speed of working varied somewhat with the group, being greater for the poor vision groups than for the good vision group. The intensity of illumination giving maximum speed, also differed for the different groups, the poor vision group reaching its greatest speed under the highest illumination, and the other two groups under 8.0 foot-candles. On reducing the illumination, however, to its original value of 2.8 foot-candles we found that the production did not return to its original value but to a value considerably above it. The same phenomenon was noted recently in an experiment in England on the relation of illumination to coal production. When a coal miner used an ordinary lamp the production was 2.47 tons; with a lamp six times as bright, it was 2.83 tons, an increase of 14.6 per cent. When the miner returned to the use of the ordinary lamp, the production did not return to its original value but still remained 5.4 per cent above it.

This failure to return to the original speed of working, or of production, when the illumination is returned to its original value makes the interpretation of the result rather difficult, and it is felt by us that before the results obtained by us can be completely understood it will be necessary to find an explanation of this peculiar phenomenon. Another question that naturally presents itself is: "Will the increased speed obtained under increased illumination be maintained, or disappear, in part or in whole, as the time goes on?" It is natural to expect that some of it at least will be maintained, but we feel that it will be necessary to make further tests to establish the facts. The tests recently carried on by the Detroit Piston Ring Company would seem to indicate that the increased speed is maintained. In connection with the tests made by Mr. Hess and Mr. Harrison the same question presents itself, namely, "Would the increase in production observed by them be maintained over a long period of time if the increased illumination is maintained?"

Ward Harrison (Communicated): Dr. Ives stated that in the New York Post Office tests the speed of work increased with the

illumination but did not drop down all the way to its original value when the illumination was again reduced to 2.8 foot-candles. I have heard indirectly of other instances where the same phenomenon has been observed. The best explanation that I have heard was that suggested by Dr. E. F. Nichols, namely that the ease of seeing under the high illumination establishes the habit of faster work and that this is not immediately shaken off when the illumination is reduced to the former low value. Likewise, the ultimate high speed of work obtainable under a high level of illumination is quite possibly not secured during the first few days of work under such illumination.

SALIENT FEATURES IN POWER STATION LIGHTING*

BY RAYMOND A. HOPKINS**

SYNOPSIS: Unusual problems are met in the lighting of power stations on account of individual arrangement of equipment, severe service conditions and exacting requirements. The successful lighting system must be reliable, economical, easy to maintain and adequately suited to the specific local requirements which requirements are found to differ throughout the station. The most reliable and economical source of energy is usually the station auxiliary bus. The distribution wiring should be of the particular quality best suited to meet power station conditions and should be designed to give the best possible voltage regulation consistent with economy. An emergency lighting system should be provided and of several possible arrangements the one giving greatest dependability should be selected. All equipment such as cabinets, switches, receptacles, lamps, globes, shades and reflectors should be carefully selected to give maximum operating convenience, long life and high efficiency. A thorough survey of a large number of existing first-class power stations gives data for the solution of a number of typical station illumination problems so selected that the designing engineer may extend the data and conclusions given to meet the requirements of any ordinary station.

GENERAL CONSIDERATIONS

Steam and hydroelectric power generating stations and substations present unusual lighting problems seldom met elsewhere in the industrial field. In the coal bunker, the firing aisle, the ash room, the switch room, and many other parts of the station, the conditions are so severe and the requirements so exacting that the design deserves very careful study. It is the intention of this paper to discuss a limited number of specific problems and to submit solutions for them, based on actual data from a large number of successful installations to the end that the designing engineer may readily extend the data and conclusions to completely cover the requirements of any ordinary station.

Reliability of the lighting system is of first importance since light is depended upon for the reading of meters and gauges, the operation of controls, the inspection of equipment and the supervision of all working parts of the station which themselves are

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essential to the continuous production of electric energy. The complete lighting system should, therefore, be of rugged construction and of ample capacity and should include spare transformers and other essential parts. Moreover, in order to provide an immediate relay against even a momentary failure of the normal lighting system, an auxiliary or emergency system should be arranged to serve all important parts of the station.

As an example to the public who support the power station by purchasing its output, the station lighting should represent the latest achievements in correct illumination. The use of wasteful and antiquated lighting equipment should be avoided and the installation should be designed to permanently secure proper illumination intensities and satisfactory operating conditions.

Maintenance, with every lighting system, is essential to successful performance. Particularly in the power station, on account of the unusual ceiling heights, the hazardous locations and the excessive dust, the problem of maintenance deserves earnest attention. Equipment should be selected which endures severe service and which is readily disassembled for cleaning and relamping, and it should be located so as to be easily accessible.

Less illumination is generally required for normal operation of the station than is required for maintenance or repair work. During normal operation there are instruments, gauges, bearings and other details to be watched and certain routine operations to be performed, but many parts of the station can be left relatively unattended except for regular scheduled inspections. These periodical inspections, however, require ample lighting throughout the station and repair work and overhauling of machines, which is often done on a rush basis, deserve the best possible lighting. It is, therefore, important that the lighting system be made flexible by providing plenty of local switching and of plug receptacles.

SOURCES OF ENERGY

A choice is generally to be made between several available sources of energy for the lighting system such as the main station bus, the station auxiliary bus, the exciter bus, the storage battery, or an outside source. The chief considerations involved in making the choice are reliability, economy and voltage regulation.

The main station bus in a direct current station is generally the most reliable and economical source for the lighting and is usually chosen on this basis, although the voltage regulation may not be all that is desired. Lamps of the 110 to 125-volt or 220 to 250-volt class are generally used and when the bus voltage is 550 or 600 volts, the lamps are grouped in series.

The main station bus in an alternating current station is in itself a reliable and economical source. When the voltage is over 2300 volts, however, the transforming and switching equipment are expensive and also constitute a possible hazard to the lighting system. Moreover, the voltage on the main bus is often varied as much as 10 per cent above and below normal at different times of the day to suit the load requirements, this condition necessitating the use of a feeder voltage regulator on the lighting circuit. For these reasons, the main bus when of over 2300 volts, is seldom used as a source for the station lighting.

The station auxiliary bus from which all motor driven auxiliaries are fed is usually considered the best source of energy for the lighting system. It is generally operated at 2300 volts and proper transformers and circuit breakers are used to supply energy to the lighting system. Since the continuous operation of the station auxiliaries is very important even under conditions of power interruption or voltage surge on the main bus, the station auxiliary bus is usually supported by at least two sources of energy, at least one of which is a prime mover. This assures a reliable, economical and usually well regulated source. A feeder voltage regulator on the lighting feeder is necessary only when the auxiliary bus for some reason does not carry a uniform voltage.

The exciter bus is not considered a suitable source for the normal lighting. It is reliable but not particularly economical and when automatic voltage regulators are used on the exciters, the voltage regulation of the exciter bus is often as great as 60 per cent above and below normal. Furthermore, the lighting system, if fed from the exciter bus, is somewhat of a hazard to the excitation system. The exciter bus is sometimes used as a source for the emergency lighting system but even this practice is not to be recommended.

The storage battery is a most reliable secondary source of energy for the lighting system and with proper charging connec-

Comparison Of Distribution Systems

(Based on equal feeder lengths and equal loads, and using system "A" as a base for comparison)

System	Diagram	Description	Current	Copper size based on current density (short feeders)				Copper size based on percent voltage drop (long feeders)			
				Copper size	Total copper weight	Percent voltage drop	Power loss	Copper size	Total copper weight	Percent voltage drop	Power loss
A		1 Ph or d c 2 Wire 110 Volt	100	100	100	1.00	100	100	100	1.00	100
B		1 Ph or d c 3 Wire 220–110 Volt	Outside 50 Neutral 0	Outside 50 Neutral 50	75	.50	50	Outside 25 Neutral 25	37 5	1.00	100
C		2 Ph 3 Wire 110 Volt	Outside 50 Common 70.7	Outside 50 Common 70.7	85.3	1.00	85	Outside 50 Common 70.7	85 3	1.00	85
D		2 Ph 4 Wire 110 Volt	50	50	100	1.00	100	50	100	1.00	100
E		2 Ph. 5 Wire 220–110 Volt	Outside 25 Neutral 0	Outside 25 Neutral 25	62 5	.50	50	Outside 12.5 Neutral 12.5	31 25	1.00	100
F		3 Ph 3 Wire 110 Volt	57 7	57.7	86.5	.865	86.5	50	75	1.00	100
G		3 Ph 4 Wire 191–110 Volt	Outside 33.3 Neutral 0	Outside 33.3 Neutral 33.3	66 7	.50	50	Outside 16.7 Neutral 16.7	33.3	1.00	100

Fig. 1.—Comparison of Distribution Systems

tions the voltage regulation is satisfactory. The cost of the battery and its poor efficiency at once prohibit its use for normal lighting but it is very commonly used as a source for emergency lighting. When so arranged the battery size is determined by the demand of the emergency lighting system plus the demand of the control system. The latter is likely to be heavy during a period of emergency since at such a time considerable switching is done. A maximum allowance of one hour for demand on the emergency lighting system at any one time is considered ample to meet the most extreme conditions. Since the control circuits constitute a very sensitive and important part of the station wiring, it is important that the emergency lighting system if fed from the control battery, be kept free from grounds or other faults which may cause trouble with the controls.

An outside service is sometimes used as a source of energy for the lighting system where the station voltage or frequency are not suitable for lighting circuits. Especially in small stations of this nature it is often found more economical to purchase energy for lighting than to install necessary transforming or converting equipment.

DISTRIBUTION SYSTEM

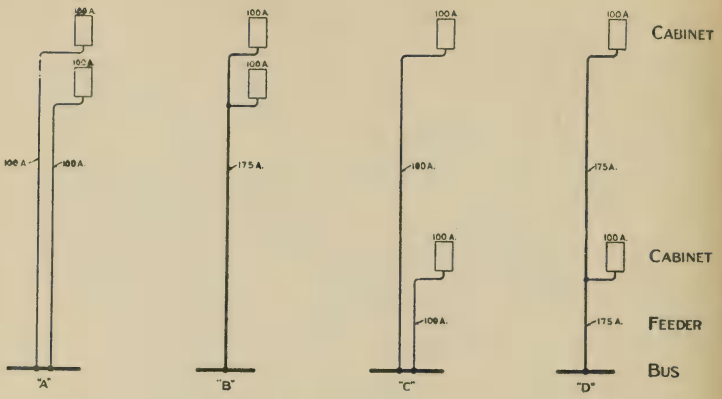
The materials and workmanship constituting the complete lighting system from the source of energy to and including the lamps should be of the best quality in order to insure dependable operation comparable to that of the major station equipment.

Data on a number of the most commonly used distribution systems are given in Figure 1. It will be seen that where the feeder is so short that the copper size is based on current density or carrying capacity, the use of one of the higher voltage systems as B, E or G results in a considerable saving in copper and in less voltage drop and power loss. Also, when the feeder is so long that the copper size is based on allowable voltage drop, the higher voltage systems result in even more saving in copper.

System B is probably the most commonly used. Being a single phase system it requires only one transformer while a polyphase system requires more than one. With a single phase system the lighting is all carried on one phase of the station, but this is seldom found objectionable.

The neutrals of systems B, E and G should always be grounded and the neutral conductor unfused. The size of the neutral should be determined by the size of the fuses in the outside conductors where the circuit is protected by fuses, since the blowing of a single fuse is liable to result in the neutral wire carrying the full load of one of the outside wires. Where a circuit breaker is used, all poles of which trip at the same time, the neutral wire need be only large enough to carry the unbalanced current. For system C the common conductor must have 1.41 times the capacity of each outside conductor. If the system is convertible the common conductor must have double the capacity of each outside. An example of this connection is found where the emergency lighting circuits are normally operated as system B, but in emergency are operated as system A by connecting the two outside conductors to the positive and the neutral to the negative.

The grouping of several cabinets on one feeder is not desirable from the standpoint of flexibility in switching, testing and maintenance but is often done for economic reasons. By referring to Figure 2 it will be noted that when two or more cabinets are located close to each other and at some distance from the bus as in A and B, the most economical arrangement is to group the



GROUPING OF DISTRIBUTION CABINETS SHOWING COMPARATIVE ECONOMIES
A & D UNECONOMICAL
B & C ECONOMICAL

FIG. 2.—Comparisons of Cabinet Groupings.

cabinets as shown in B. This not only takes account of the fact that one feeder costs less than two, even when equal weights of copper are involved, but also of the fact that the single feeder will contain less copper on account of diversity between cabinet loads. On the other hand when the cabinets are scattered as in C and D, the most economical arrangement is separate feeders as shown in C. The common feeder as shown in D could be used to advantage by fusing the feeder just beyond the first cabinet but fuses in the feeders at other points than at the main switchboard are not to be recommended.

Distribution cabinets of various styles are available and the choice depends on a great many local conditions. Main fuses are necessary unless the cabinet buses are protected by the feeder main fuse. The main switch in the cabinet is optional. It is convenient for changing of branch fuses, for making changes in the cabinet wiring and for controlling the entire cabinet in cases where control of this kind is desirable. The main switch is sometimes electrically operated so that the entire cabinet can be controlled from a distance. Such a control is convenient for the distribution cabinets supplying large turbine rooms, since the cabinets can be located up near the lamps and the control switches can be located at a convenient place on the turbine room floor. Magnetic switches are available in two types, one of which is operated by a

momentary contact control switch and the other by a single pole, single throw control switch. In laying out the lighting system it will be found that each type has distinct advantages over the other to meet certain conditions.

Branch fuses are necessary in all cases. At present two-pole fuses are required by code but it is expected that in the near future single-pole branch fuses will be allowed under specified conditions. Branch switches are optional. They are unnecessary where the cabinets are located with respect to the centers of distribution and are used only as fuse boxes, the control being entirely by local switches. On the other hand, branch switches are needed where the cabinets are located not necessarily in the centers of distribution but at convenient control points, and are used to control the lighting without local switches. The latter arrangement has the disadvantage that lights may be turned off by mistake in rooms where they are urgently needed.

Flush type and surface type, dead front and open front cabinets are available and the choice depends upon their locations. Directory frames are always convenient when replacing fuses. Wiring gutters are necessary in the majority of cases and it is convenient to provide wider gutters at the tops and bottoms than at the sides, since most of the wiring enters the cabinet at the top and the bottom.

Coding of the branch wiring where the neutral is grounded is becoming standard practice. It is convenient to use a white or light colored braid for the grounded wire and the usual black braid for the other wires. The shell sides of all sockets and receptacles are connected to the white wire, and all single-pole switches are placed in the black wire.

Special insulation is very desirable in boiler rooms and in condenser rooms where the wire is subject to severe heat and moisture conditions. In these locations the ambient temperature is often above the safe temperature for rubber insulation, and escaping steam sometimes produces condensation which is liable to saturate the braid. Several types of insulation and covering have been tried including asbestos compounds, fibre compounds, waterproof impregnations and varnished cambric with lead covering. It is very difficult to find an insulation and braid which will permanently resist both the moisture and the heat.

Generally if it is heat-resisting, it quickly absorbs moisture and on the other hand if it is impregnated to resist moisture the heat quickly dries out the impregnating compound. Varnished cambric insulation with lead covering is quite satisfactory but very expensive. Varnished cambric insulation with braid covering gives very good results. None of the usual rubber compounds are suitable, but certain vulcanized compounds are available which are satisfactory for boiler room use. Much trouble from excessive temperature can be avoided by carefully selecting the locations of conduit runs.

EMERGENCY LIGHTING

The emergency lighting system has been mentioned a number of times in the preceding paragraphs. The most carefully designed and maintained normal lighting system is not infallible. In case of system disturbance or loss of a lighting transformer or other accident that extinguishes the normal lighting system it is of utmost importance to station operation that the emergency lighting system be automatically put into operation at once. The important parts of the station to be covered by emergency lighting are water columns, boiler gauges and meters, stoker and fan controls, boiler feed pumps, turbine gauges and controls, turbine auxiliaries, valve controls, oil circuit breakers and disconnecting switches, lighting transformer and switch rooms, switchboard rooms, load dispatcher's office and all stairways and passages.

Three commonly used systems of emergency lighting connections are shown diagrammatically in Figure 3. In each system the emergency wiring is segregated from the normal wiring by the use of separate conduits, cabinets and outlets. It is often found convenient, however, and perfectly satisfactory, to use combination cabinets with barriers separating the normal from the emergency circuits. One of the three systems shown is generally selected although it is sometimes found in working out the details that combinations of all three are necessary.

System A consists of a number of small auxiliary lamps arranged to burn normally and in emergency on the emergency source. Since the lamps are kept burning continuously and are always fed from the emergency source, the number and size of the lamps must be kept small so as to conserve energy. The lamps therefore cannot be used to supply any portion of the normal

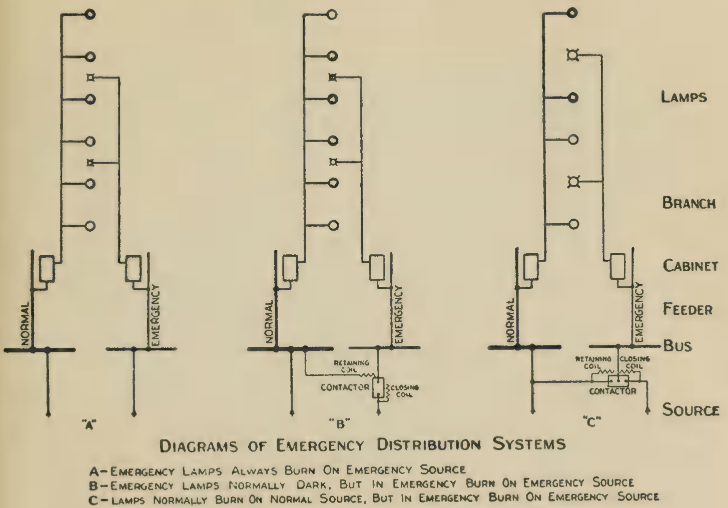


FIG. 3—Diagrams of Emergency Distribution Systems

illumination but must be considered as auxiliary or supplementary to the normal lamps. Thus each gauge, for instance, must have two lamps, a normal and an emergency. Local switching is not provided for fear the lamps will be turned off locally at the time an emergency occurs. The feeders are sometimes switched at the main switchboard and the operator is instructed to turn off the lights during the day in those portions of the station which do not require lighting in the daytime. This emergency system being supplementary to the normal system is apt to be robbed of lamps and fuses and to otherwise become deteriorated, since under normal conditions its loss is not felt. The system therefore, requires rigid routine testing and maintenance.

System B consists of a number of small auxiliary lamps arranged to be normally dark but in emergency to burn on the emergency source. Somewhat larger lamps can be used than in system A, since they burn only in case of emergency, but as in A, all gauges and other vital points must have duplicate lamps. Local switching is not desirable. The main switch for the entire system consists of a contactor, normally held open by a potential coil energized from the normal source, but automatically closed by energy from the emergency source, whenever the normal

potential fails. This being a supplementary system, requires the same rigid routine testing and maintenance as system A.

System C consists of a carefully selected portion of the normal lamps to be designated as emergency lamps and arranged to burn normally on the normal source and in emergency on the emergency source. The size and number of lamps, as with system B, are limited only by the energy available at the emergency source for the short time that the emergency exists. Moreover, since the lamps burn normally on the normal source, no duplication of lamps is required at gauges and other similar places. Local switching can be provided with perfect safety because the emergency lights are required for normal operation and will always be switched on when needed. It is important, however, to arrange the switching so that where an emergency light and a normal light occur in the same room for instance, both lights will be switched at the same operation. This has been successfully done by using a two-pole switch, wiring one pole in the emergency circuit, the other in the normal circuit. Likewise, in a large interior, such as the turbine room, a single emergency circuit can be controlled simultaneously with a number of normal circuits by the use of a double pole switch, one pole of which controls the emergency circuit directly, the other the normal circuits collectively through a contactor cabinet. The main switch for system C consists of two contactors interlocked so as to form a double throw switch. Normally the switch feeds the emergency lights from the normal source but in the event that the normal source fails, the contactor is automatically thrown over by energy from the emergency source so as to feed the lamps from the emergency source. The action is reversed when the normal potential is restored. Since with this system the lamps form a part of the regular lighting, their loss is immediately felt and therefore this system is more likely to be properly maintained than either of the other two systems.

EQUIPMENT

All equipment including cabinets, switches, receptacles, lamps and reflectors should be of especially rugged design consistent with the reliability required of the lighting system. Rugged construction can be obtained by the use of heavy conduit and outlet fittings, cast iron outlet boxes, cast iron hoods for supporting

reflectors, porcelain enameled steel reflectors, heavy glassware, wire guards, rubber and steam gaskets, substantial sockets, positive locking devices on all screws supporting reflectors and other similar devices. Long supporting stems should be made flexible by the use of double strip flexible steel conduit or of flexible metallic steam hose. Aligners or flexible joints with rigid stems also give some degree of flexibility. Heavy equipment should not be supported from outlet box covers but should be attached directly to the boxes by substantial threaded fittings.

All equipment should be easy to clean, relamp and maintain This is of especial importance in the electrical bay where the lights are sometimes located in hazardous places. The ceiling lights in the turbine room are reached from the crane and it is very convenient to be able to unhook a complete unit and lower it to the floor for cleaning.

Steelware is generally used in the boiler house and condenser rooms and glassware is generally used in the turbine room, electrical bay and offices. Glare should be avoided by using bowl enameled lamps in all open reflectors and by using good quality diffusing glassware of large size for closed units.

Receptacles of the marine type are desirable for the ash room, boiler room and condenser room and are often used throughout the station for purposes of standardization. The screwed cap excludes dirt and moisture when the receptacle is not in use. Heater receptacles are often required in hydroelectric stations and substations where steam heat is not available and in electrical bays of steam stations where steam heat is objectionable. It is desirable to provide three-wire receptacles so that the heater frames may be grounded.

DESIGN DATA

In some parts of the station, such as the turbine room and the offices, the usual flux of light methods of design can be applied to advantage. For the majority of the station, however, the chief problem is to avoid shadows and glare and to locate the individual lights effectively with respect to the equipment and it is found that the efficiency of utilization and the watts per sq. ft. are themselves of very little assistance.

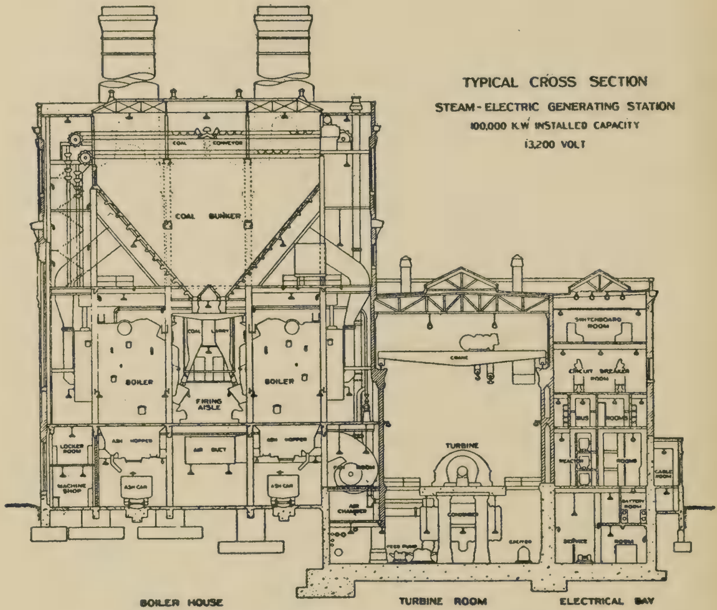


Fig. 4—Typical Cross Section of Steam Electric Generating System.

Figure 4 shows a cross sectional view of a typical coal burning steam-electric generating station of 100,000 kw. installed capacity, generating and delivering energy at 13,200 volts. The majority of the specified problems discussed below are illustrated in this cross section.

The design data given are typical of the actual conditions found in a recent survey of a number of first class power stations. The illumination intensities are the direct results of tests made in these stations with a Macbeth illuminometer. In making the tests no attempt was made to clean or renovate the lighting equipment before test, and the intensity values recommended are net, depreciated values. It is expected that in a new installation they would be from 20 to 40 per cent higher in order to allow for depreciation.

Fundamental design data compiled from a number of representative steam stations comparable to the one illustrated in Figure 4 are as follows:

	Boiler House	Turbine Room	Electrical Bay	Entire Station
Lighted Floor Area, sq. ft.	55,000	45,000	35,000	135,000
Number Normal Lights	300	250	400	950
Number Emergency Lights	120	50	140	310
Total Number Lights	420	300	540	1,260
Connected Normal Watts	31,000	49,000	33,000	113,000
Connected Emergency Watts	8,500	10,500	11,000	30,000
Total Connected Watts	39,500	59,500	44,000	143,000
Total Watts per sq. ft.	0.71	1.32	1.26	1.06

COAL PILE AND YARD

The coal pile and yard are not unlike any industrial plant yard. Ordinary operation of the station does not require night work in the yard but conditions often arise which make night work necessary and the lighting system should adequately meet all such demands. Emergency lighting is seldom used in the yard. Either flood lighting from projectors or local lighting from pole tops can be successfully applied. The former is generally less expensive to install and more easily maintained. The boiler house roof and the coal conveyor house offer convenient locations for projectors. Switching should be located in the boiler house near the door used by the workmen. It is convenient to use standard lamps in the projectors and to select them of the same size as those used elsewhere in the station.

For unloading coal and conveying coal to the crusher, an average intensity of 0.7 fc. is desirable. With 1000 watt projectors this requires about 0.1 watts per sq. ft. For roadways, an intensity of 0.2 fc. is sufficient and with 200 watt projectors this requires about 0.03 watts per sq. ft.

COAL BUNKER AND CONVEYOR

The coal bunker and conveyer illustrated in Figure 5 is generally the dustiest part of the station. The coal is usually crushed in the yard and conveyed by belt or bucket up over the bunker where it is dropped into the bunker. The crusher house, the conveyor housing and the bunker are usually provided with natural light during the day when most of the work is performed but must have sufficient electric light for operation at night in cases of necessity. Emergency lighting is required only for safe passage and should constitute 15 per cent of the total wattage.

Bare lamps are often used but better results are obtained by adding porcelain enameled steel reflectors. Outer globes and wire guards should be used where there is danger of mechanical injury. Lamps should be located within easy reach for cleaning and this is an important consideration, especially over the bunker, where a fall by the cleaner might be very serious. Three-way switching is usually necessary. An intensity of 2 fc. is desirable and with 75- or 100-watt lamps this requires 0.5 watts per sq. ft.

FIRING AISLE

The firing aisle illustrated in Figure 6 is the most important part of the boiler house. Here are located the water columns, steam gauges, draft gauges and the controls for the larry, stokers, fans and auxiliaries. In many stations the firing aisle receives no natural light although the present tendency is to dispose of the coal bunker at the end or middle of the building so as to allow a skylight to be located over nearly the entire length of the firing aisle. The normal lighting should be adequate for operation of the boilers both night and day. The emergency lighting should be sufficient to allow full operation without normal lighting which means that 25 per cent of the general lights and all of the local lights should be on the emergency system. If general overhead lighting is used the lamps should be carefully located and properly shielded to avoid glare in the eyes of the operator when looking upward at the water columns and steam gauges. These overhead lights must also be hung above the larry and this, of course, puts them in a difficult position to maintain. On account of these limitations, it is sometimes considered satisfactory to leave the upper part of the firing aisle generally dark with strong local lights on the water columns and gauges.

The water column being located some 30 ft. above the floor but at the same time requiring constant watching by the operator, deserves very careful consideration. The light should preferably be directed from below so as to avoid specular reflection from the gauge glass. Moreover, the lighting equipment must be very rugged in order to withstand the severe force of an exploding water glass. Being arranged to face upward it must have some efficient means of removing the dust which quickly accumulates. The water column illuminator shown in Figure 7 has been found

Fig. 5—Coal Conveyor and Bunker.

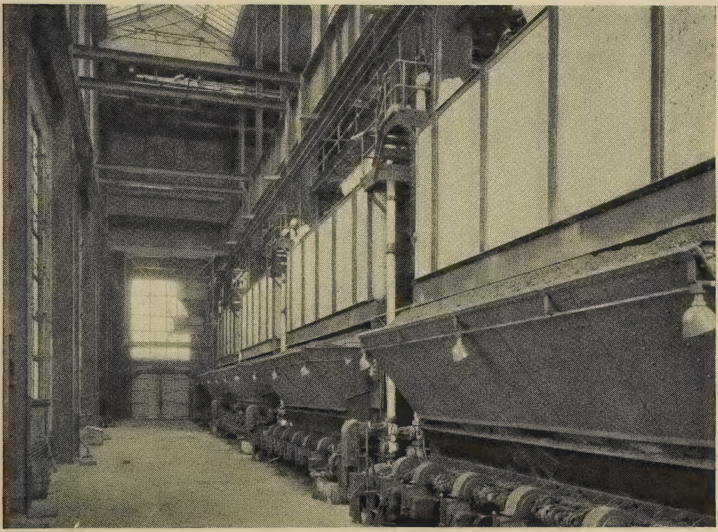


Fig. 6.—Boiler Room Firing Aisle.

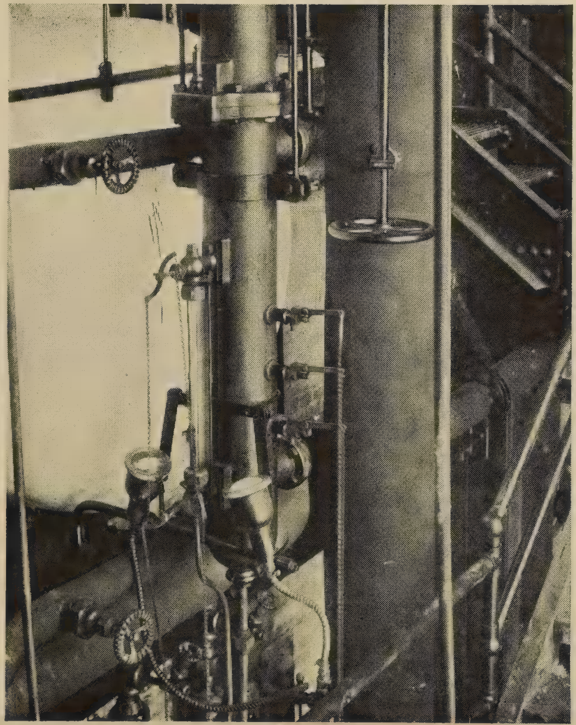


Fig. 7.—Water Column Illuminator.

Fig. 8—Ash Room.

well qualified for this severe duty. The two beams of light from the two 40-watt lamps are focused by the lenses to impinge on the meniscus of the water column and cause it to glow so that it can be readily seen from any part of the firing aisle. A series of small holes on the casing around each lens are arranged for connection to the station compressed air system or to the forced air duct and the streams of air effectively prevent the accumulation of dust. The device has always proved its ability to withstand water glass explosions due to its general rugged construction and to the special heat-resisting quality of its lense.

The steam gauge which is some 20 ft. above the floor, the clock, and the load indicator should also be lighted from below to avoid reflection. Excellent results are obtained by using a single 40-watt unit of the water column illuminator just described.

The gauge board generally contains a group of indicators and gauges and is successfully lighted by one or two 75-watt angular steel reflector units.

The stokers and drive mechanisms are generally located under the hoppers. These are adequately lighted by 75-watt angular reflectors hung from the hoppers. The walkway over the hoppers and the tops of the hoppers themselves should be well lighted since this walkway is provided for the use of the operator while inspecting the contents of the hoppers and breaking up masses of coal that may become clogged. Deep bowl or RLM units of 100-watt size are satisfactory. They should, of course, be switched locally so as to be dark always except when actually required for the above mentioned operations.

The larry requires one or more 75-watt deep bowl or angular reflectors in the cab to light the controls and weighing scales. It is also desirable to supply one or two 100-watt angle reflector units for each chute to light the end of the chute and the hopper during the dumping process. The lights on the larry are generally wired in series circuits so as to be fed from the larry motor circuit.

At the throat of the bunker one or more 75-watt reflector units may be used advantageously to assist the operator in opening the gates and discharging coal into the larry.

BETWEEN AND BACK OF BOILERS

Between the boilers and back of the boilers the passages require sufficient lighting to allow the operators perfect freedom

about the station. The emergency lighting should constitute 20 per cent of the total wattage. Stoker drives which may be between boilers and important valves which are often behind the boilers require particularly good emergency lighting. These passages are satisfactorily lighted with 100- or 150-watt RLM units. An average intensity of 3 fc. is desired and this requires 0.6 watts per sq. ft.

OVER BOILERS

Over the boilers are walkways for inspecting the boiler tops, safety valves and water columns and for operating non-return and other valves. The emergency lighting should provide for safe passage over the walkways and for operation of the non-return valves. Generally 50 per cent of the walkway lighting should be on the emergency system. Lights located over the boilers should be well back from the firing aisle so as to avoid glare in the eyes of the operator below. They should also be switched locally since they are only needed occasionally. Generally a 100-watt RLM unit over each boiler is sufficient. For the walkway over the front of the boilers and also for the walkway at the back of the boilers 50-watt marine brackets may be used with outer globes and wire guards. Those for the front walkways should be located close against the columns on the side away from the firing aisle so as not to interfere with the reading of the water gauges.

ASH ROOM

The ash room, Figure 8, presents a peculiar problem because most of the equipment to be operated is on the ceiling. The railroad cars are pushed under the ash hoppers, the hopper gates are opened and the ashes drop into the cars. The ashes are generally mixed with water so that the lighting equipment is likely to be injured by steam and acid as well as by dust. Emergency lighting is required only for passage and should constitute 15 per cent of the total wattage. Since daylight is generally excluded from the ash room, some of the lamps should burn continuously. Enameled steel angle reflector units of 100- to 150-watt size or smaller units of the totally enclosed and wire guarded marine type are found satisfactory depending upon conditions. They should be located so as to light the controls without causing

glare in the eyes of the workmen. The forced draft duct often occupies the center bay and under this should be located 75- or 100-watt RLM units for general illumination. Receptacles should be used to facilitate repair work and the ash room is one of the places where marine type receptacles are necessary. The ash room lights should be switched locally at the columns since work is done only in portions of the room at a time.

TURBINE ROOM

The turbine room, Figure 9, presents the large interior problem. The crane spans the entire room and ceiling lights must be located above the crane trolley. Bracket lights if used must be close to the walls to avoid the crane hook. The horizontal component of illumination is important in order to read the vertical gauges. During normal operation an average horizontal intensity of 4 fc. is sufficient but when a generating unit is down for repairs an intensity of 8 fc. is desirable. Consequently a flexible switching arrangement is needed. A very convenient switching arrangement consists of one or more cabinets with branch switches and with magnetically operated main switches. The lighting for the entire room is controlled by one or two pilot switches and the amount of illumination is varied by adjusting the branch switches. Emergency lighting should be provided to give an average of 2 fc. which under stress of necessity will permit full operation. With prismatic reflector units of 750-watt size and with light buff colored brick walls it is found that an intensity of 4 fc. requires .5 watts per sq. ft.

CONDENSER FLOOR

The condenser floor often presents some confusion in the mind f the lighting designer. The turbine usually rests on a platform olated from the rest of the building and standing on its own oundation. Under and around the turbine platform are ssembled the various station auxiliaries, such as pumps, fans, alves and controls. The lights in general must be hung from he turbine platform or supported from the condenser and must e located below the mass of large and small pipes that often ccupy most of the space overhead. Parts of the condenser floor re sometimes lighted naturally but often the entire room receives

no daylight. Constant supervision of the auxiliaries is a vital part of the station operation. Emergency lighting should constitute 20 per cent of the total wattage. Local switching should be provided so that lights may be turned out around machines which are shut down. Receptacles are needed frequently for inspection and repair work and should be of the waterproof type. With RLM enameled steel reflectors and 100- or 150-watt lamps it is found that an intensity of 4.0 fc. requires 0.75 watts per sq. ft. of working space.

BATTERY ROOM

The battery room requires acidproof equipment. It is customary to use a totally enclosing prismatic reflector which screws into a cast-iron box embedded within the ceiling concrete so that only the glass itself is exposed to the action of the acid-laden fumes. The switch is placed outside and no receptacles are provided. Emergency lighting should constitute 25 per cent of the total wattage. Battery rooms have sometimes been painted black but this is unnecessary since light-colored acid-resisting paints are now available. With light gray walls and ceiling and with 75-watt lamps in totally enclosing prismatic reflectors, it is found that a density of 1.0 watt per sq. ft. gives an intensity of 4.5 fc. which is considered satisfactory.

BUS ROOM

The bus room which is purely a bus room without switches or other operative equipment does not present a serious problem. The lighting should provide for reading the captions over the cells and for inspecting and cleaning the insulators and copper work. In order to effectively light the spaces between the horizontal barriers, it is advisable to hang the lamps on stems, to use diffusing glassware and to provide light colored walls. Where stems can not be used, receptacles for portable lamps should be provided. Local switching is desirable and also three-way switching when the room is entered from both ends. Emergency lighting is needed only for safe passage and should constitute 20 per cent of the total wattage. An illumination of 3 fc. on horizontal 30″ plane and of 1.5 fc. on the face of the bus structure is desirable. With white walls and ceiling and with 75-watt

FIG. 11.—Switchboard Room Lighted by Concealed Sources with Prismatic Glass Ceiling.

FIG. 12.—Night View of Outdoor Switching Station.

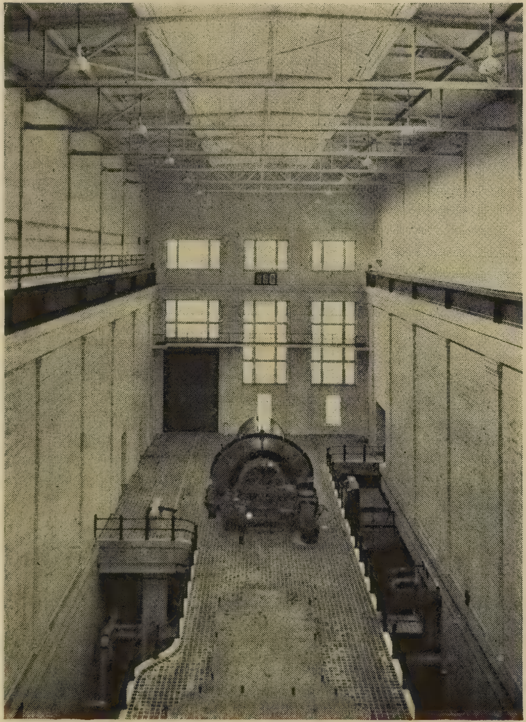


FIG. 9.—Turbine Room.

FIG. 10—Circuit Breaker and Disconnection Switch Room.

prismatic units, this requires 1.25 watts per sq. ft. With red brick or concrete walls and bus structure the wattage per sq. ft. would need to be increased to 1.75.

SWITCH ROOM

The switch room, Figure 10, generally contains oil circuit breakers and disconnecting switches. This equipment requires very close supervision and careful inspection. The disconnecting switches are often opened and closed manually by means of a wooden pole with a hook on one end which is inserted into a ring or eye on the switch blade. For normal operation the most exacting requirements of the lighting system are to provide for clear reading of the captions over the compartments and for operation of the disconnecting switches. For maintenance the lighting should cover the breaker mechanisms and all insulators and copper work. Receptacles should also be provided for extension lamps for inspecting the inside of the breaker cells. Local three-way switching is desirable. Emergency lighting should be sufficient for operation and should constitute 30 per cent of the total wattage. It is very important that the operator shall not become confused as to the particular conductors and equipment constituting the circuit he wishes to find, and as an assistance to him the barriers separating circuits are generally striped in a pronounced color. The compartments are from 5 ft. to 7 ft. wide. It greatly assists in the marking of the compartments if the lamps are placed regularly with respect to the compartments; that is, on the beams between the compartments or in the centers of compartments. Good diffusion should be obtained by the use of diffusing glassware and light walls.

Among the many arrangements of equipment found in the switch room, two typical cases deserve special consideration, namely, subcell disconnecting switches and ceiling disconnecting switches. Generally the room is so narrow that ceiling lights do not adequately illuminate the subcell disconnecting switches and wall lights are necessary. The wall lights should be located either on center lines of compartments or between compartments. With concrete walls and barriers, and with 100-watt prismatic reflector units on the ceiling spaced 14 ft. apart and 50-watt totally enclosed guarded units on the walls, spaced 7 ft. apart,

the intensity on a horizontal 30-inch plane is 4 fc. on the vertical front edge of the cell top 2 fc. and on the disconnecting switches 1.5 fc., and these valves are very satisfactory.

With disconnecting switches on the ceiling the only logical location for lights is on the beams between compartments. Needless to say, a very mild well diffused light should be provided by the use of small lamps, good quality closed bottom diffusing glassware, and white walls. The best results are obtained by using one unit under each beam which brings the spacing 5 ft. to 7 ft. If the barriers are painted white, 50-watt units are satisfactory. If the barriers are of gray concrete or red brick, 75-watt units are needed.

CABLE ROOM

The problems presented by the cable room are somewhat similar to those of the bus and switch rooms. Generally considerable work is done in the cable room in connection with testing and altering cables and the lighting should be designed with this in mind. Local switching is desirable. Emergency lighting is needed only for passage.

SWITCHBOARD ROOM

The switchboard room is the control point for the entire electrical portion of the station and should be perfectly lighted at all times. Emergency lighting is probably more important in this room than in any other part of the station. It should constitute 30 per cent of the total wattage and in all cases should cover the entire switchboard. The meters and instruments are arranged on vertical boards and the controls are arranged on either vertical boards or benchboards. The chief requirement of the lighting is to provide uniform, soft illumination on these instruments and controls and to avoid reflection and glare from the instrument cases. Two general schemes of switchboard room lighting are in successful use and deserve mention: one from visible sources, the other from concealed sources.

Switchboard room illumination is from visible sources. The prismatic reflectors and bowl enameled lamps are mounted in front of and above the board, the position being designed to avoid direct reflection from the meters. With a light colored ceiling and

using 100-watt lamps a density of 0.75 watts per sq. ft. gives an intensity of 3.5 fc. on a horizontal 30-inch plane, and 2.5 fc. on a vertical plane through the instrument scales.

Switchboard room lighting from concealed sources has been accomplished by two methods, first by the use of a diffusing glass ceiling and second by the use of a prismatic glass ceiling. In either case the ceiling is lighted during the daytime by a skylight located directly over the ceiling and at night by prismatic reflectors and clear lamps hung between the ceiling of the skylight. In the first method the lamps are so placed as to direct the light obliquely toward the switchboard and the glass is simply of the diffusing or ripple type and serves to hide the sources. In the second method, which is illustrated in Figure 11, the light from the skylight and from the lamps is considered to reach the glass ceiling in a generally vertical direction and the glass is designed to redirect the light obliquely against the switchboards. The glass is smooth on top and prismatic on the bottom. It is realized, of course, that better results can be obtained by placing such glass with the prisms upward or probably still better results by using glass with prisms on both sides. The difficulty of keeping the upper surface of the glass clean if other than smooth, however, is thought to outweigh the advantages of having prisms on the upper side. The wattage required is practically the same for either kind of glass. With prismatic reflectors and 75-watt clear lamps a density of 1.5 watts per sq. ft. of glass ceiling will give under the glass ceiling an intensity of 8 fc. on a horizontal 30-inch plane and of 3 fc. on a vertical plane through the instrument scales and these values are very satisfactory.

OFFICES

The general offices require no particular departure from commonly accepted good office lighting practice. The load dispatcher's office, however, requires sufficient emergency lighting for satisfactory operation without the normal lighting. The load dispatcher's office usually contains a mimic switchboard or system diagram which requires special lighting either by means of general lighting on its front surface or by means of miniature lamps used to indicate switching operations.

OUTDOOR STATION

The lighting of the outdoor station must usually provide for the manual operation of disconnecting switches. Emergency lighting is seldom required.

Being an open structure the outdoor station can be lighted by projectors or flood lights when suitable supports are available for the light sources. Care must be exercised, of course, to locate the lights so that they will not blind the operator. It is also desirable to have the lights scattered so as to avoid shadows.

A second method which has proved successful uses totally enclosed diffusing glassware in weatherproof fittings. An example is shown in Figure 12. As with the indoor switch room, it is very important to have the lamps small in proportion to the glassware and to provide glassware of good quality so as to avoid glare.

DISCUSSION

F. C. CALDWELL: Mr. Chairman, in line with what the President has just said, the Dayton Power & Light Company have added one more feature to the lighting of their power station. As an example of how it should be done they wanted the public to see a well lighted plant. Consequently, they had in mind in the arrangement of their lighting the effect produced at night, from the outside, and lighted up the rooms and windows so that passers-by could see a brilliantly lighted building.

JULIUS DANIELS: There is one thing I want to mention: I hope that in the designing of the installation of a central station power plant, sufficient provision is made for a sign on the station buses. A sign load for a station of 100,000 K. V. should be approximately 75 kilowatts and that should go on the station lighting service.

Another point that came to my mind was that sufficient lighting should be furnished in back of the switchboard so that the secondary wiring can be tested and checked.

H. T. PLUMB: In connection with the last speaker's remarks I have in mind a station where we flood-lighted the outside of the building so that people could see it for miles in every direction.

In the pictures shown, it seems to me there is a great deal of glare present in some positions. For example, when the man was looking at the switchboard instruments, there were some glaring fixtures hanging back of the switchboard.

All such things can be avoided by suspending the fixtures behind beams, or by dropping boards between the operator and the fixtures.

Davis H. Tuck: (Communicated) For illuminating coal crushing and pulverising equipment, where there is an excessive amount of black dust in the air, there has been developed a gas tight prismatic refractor unit having a symmetrical or asymmetrical distribution. The refractor has a closed bottom and is held in a gasketed chamber so that the only exposed surface is smooth glass. The lamp bulb and inner surface of the refractor is thus protected from the coal dust by a gas tight chamber.

For lighting turbine rooms where the lights must be placed above the craneways and where there is a switch room balcony on an approximate level with the craneway, prismatic intensive type reflector units similar to those described by Mr. Hopkins, have been built with an aluminum cover spun over the reflector, so that the transmitted light in the direction of the switch room is cut off but the transmitted light to the ceiling is allowed to pass through. Such an installation is in operation in the New Colfax Station of the Duquesne Light Company, Pittsburgh. This installation was designed by the D. P. Robinson Company to eliminate the glare from the switch balcony and at the same time maintain the daylight effect given by the indirect component of light to the ceiling.

A method of installing lighting units has been used which makes maintenance easy. Type T condulets are used and the downward leg terminates in a hook. The stem of the unit terminates in a loop and a piece of reinforced cord is used to plug in the unit on the condulet cover. The unit is unhooked, the plug pulled and the entire lighting fixture is lowered to the floor for cleaning.

ARTIFICIAL ILLUMINATION IN THE IRON & STEEL INDUSTRY*

BY W. H. RADEMACHER**

SYNOPSIS: During the last decade the application of artificial light in the Iron and Steel Industry has undergone marked changes with a distinct trend toward betterment. The modern incandescent lamp has rapidly displaced other forms of illuminants and in conjunction with modern reflecting equipment is today recognized standard. Altho much of the work involved in this industry is of a rough nature and does not necessitate lighting intensities of a relatively high magnitude, the requirements are nevertheless far from unimportant. Chief among the credits to the account of modern lighting are safety insurance and the twenty-four hour day, attended by the successful coping with keen competition and the affection of economies in production.

The selection and application of equipment for the various areas embraced in plant structure are exceptionally important problems, dictating as they do the success or failure of the resultant illuminating effect.

In this paper the requirements of the various sections and operations are treated in detail, recommendations being offered as to the best practice. Photographs illustrating the application of the modern principles discussed accompany the text.

INTRODUCTORY

The information embodied in this paper is based on an investigation and analysis of existing conditions in twelve of the leading steel mills located in the Pittsburgh, Youngstown and Chicago Districts. In view of the number of mills surveyed, their diversified location and their standing in this field of manufacture it is believed that the data presented may be considered as fair criteria of the practice in the industry as a whole.

The basic objectives of the investigation were to study building structure, manufacturing operations and general working conditions from the standpoint of lighting requirements; to determine the type of lighting equipment in present usage, to ascertain the lighting intensities employed and to compare these values with those reported in the previous surveys. It was further desired to analyze the suitability of the lighting equipment used and intensities in vogue with a view toward confirming their application or suggesting revisions if such procedure seemed advantageous.

*A Paper presented before the Annual Convention of the Illuminating Engineering Society, Lake George, N. Y., September 24-28, 1923.

**Edison Lamp Works of G. E. Co., Harrison, N. J.

In establishing a view point for the consideration of this discussion it should be noted that steel manufacture as now practised is essentially a twenty-four hour process. This is necessarily so for economic reasons. Very hot, even to the point of incandescence, and moulten metal of great bulk enters into most processes, and only thru the maintenance of temperatures and elimination of appreciable reheating is fuel consumption and production time—in a word, cost—kept within present low limits.

STRUCTURAL CONDITIONS

To fully understand the lighting requirements of any industry it is necessary to become familiar with the structural arrangements enclosing or affecting the areas to be lighted.

The working areas of the typical mill may be divided into two broad classes, as (1) Exterior,
(2) Interior,

The former consists of the throughfares and yards and the latter all enclosed or covered operations. These two groups, for the purpose of discussion and further analysis, may be subdivided. The exterior, with regard to the activities within the areas involved, as

(1) Throughfares,
(2) Active Working Areas,
(3) Storage Areas.

The interior, with regard to the grade of work carried on as

(1) Rough,
(2) Medium rough,
(3) Medium,
(4) Fine. See Table I

All exterior work may be included under the first classification.

The thoroughfares about the steel mill are of three types; foot, vehicle and railroad, the former are usually beaten earth or cinder paths leading from building to building and from one point in the yards to another. These paths cross railroad tracks, wind between buildings, pass storage piles, dumps, etc., and there exists an ever present possibility of obstructions being cast in the route of the unsuspecting pedestrian. The vehicle roads are of much the same character as the foot paths, though of course wider. The railroad tracks are connecting arteries between various yard points and

buildings, providing a line of travel for locomotive cranes, switching engines, ingot, ladle, stock and freight cars etc. Considerable switching is involved in the handling of traffic, the burdens carried are often of a treacherous nature such as brimful ladles and red hot ingots, and danger lurks at every crossing and curve.

The active working areas of the typical mill yard include such sections as the ore dumps, stock piles, skull cracker yards, mould yards and in some cases, cooling tables and loading and shipping yards. The actual work in these areas is of a rough but usually hazardous nature as stumbling obstructions are common and cranes are constantly moving about with loads of material.

The activities on the thoroughfares and within the active working areas are practically as intense during the hours of dark, ness as during daylight.

The storage areas are those sections set aside for the dead storage or surplus stocks of coal, scrap iron, etc.

Interior conditions in steel mills are far different than those encountered in any other industry. The buildings housing what have been termed the rough and medium-rough operations are usually very large, covering considerable ground area—the widths commonly range from 30 to 100 ft. the lengths from 100 to 600 ft,, and the heights from floor line to roof trusses from 25 to 60 ft. The roofs are invariably of the steel truss supported monitor type. Heavy duty overhead cranes traverse most of the buildings and are in almost constant operation carrying heavy machine parts, stock, and incandescent and hot metal in bars and ladles. The atmosphere within these buildings is almost constantly charged with steam, created by water in contact with the hot rolls and metal and rising from the water jackets of furnaces, together with graphite particles from the converters and much smoke, ore, and fuel dust. Also by virtue of these same conditions equipment and surroundings—floors, walls and ceiling—are dark and sooty making them decidedly ineffective from the standpoint of light reflection.

The machinery and equipment is usually widely spread out covering a considerable part of the floor area with various parts projecting here and there about the areas traversed by the workers. The transfer rolls, cooling tables and many of the active machine parts are located at a waist high position. The footing is usually rough, the floor area being broken up by machine parts and material

either permanently located or strewn about during the processes involved in manufacture. Narrow bridges with steep abrupt approaching steps or tunnels entered by steep narrow stairways afford the common means of crossing from one side of the buildings to another. In furnace buildings the equipment is usually lined along the sides, the central floor area being occupied by charging materials, charging machinery and the various equipment used in processing.

Those buildings housing operations of what are classed as a medium nature are much the same in their general construction and arrangement as those described above but the surroundings are usually somewhat lighter and the atmosphere less fogged, the work of this class usually involving the handling and working of cold metal.

Those operations classed as fine are rather distributed in location, some of them such as certain kinds of inspection work being carried on directly adjacent to the manufacturing processes while others, such as tin plate sorting, are most frequently handled in typical medium sized factory buildings.

CLASSIFICATION OF PROCESSES

The following tabulation (Table I) gives the author's conception of the proper classification of areas and operations under the headings previously mentioned.

Rough operations may be defined as those requiring no discrimination of detail and involving the handling of only bulky materials.

TABLE I

CLASSIFICATION OF IRON AND STEEL MILL WORK WITH REGARD TO VISUAL REQUIREMENTS

Rough	Medium Rough	Medium	Fine
Yards	Blast Furnaces	Chipping	Tin Plate
Thoroughfares	Cast Houses	Cold Rolling	Sorting
Stock Houses	Mixing Houses	Close Shearing	and
Open Hearths	Bessemer Sheds	General Inspection	Inspecting
Soaking Pits	Stripping Sheds	Wire Drawing	
Reheating Furnaces	Blooming Mills	Pipe Threading	
Puddling Furnaces	Structural & Rail Mills	Nail Making	
Annealing Furnaces	Rough Shearing	Pickling	
	Rod & Tube Mills	Tinning	
	Hot Sheet Mills	Machine Shops	
	Cooling Tables	Power Houses	
	Warehouses		

Work classed as Medium rough is that involving some discrimination of detail but not of a close or accurate nature and applying in general to the manipulation of hot metals.

Medium operations are those requiring comparatively close discrimination of detail and in general the processing of cold metal.

Fine work is that involving close application and accurate visual perception as is required for inspection.

ESSENTIAL FEATURES OF OPERATION

The following brief sketch of the essential points of the manufacturing processes and their visual requirements is given so that knowledge will be had of all conditions bearing upon the problem of light application. Attempt has not been made to give a complete explanation of the theory and processes involving as such is not within the scope of this paper.

The function of the thoroughfares has already been fully covered. Workers must be able to find their way about with celerity and safety, stored material, tracks, crossings and obstruction should be easily visible. Vehicle roadways should be clearly defined to permit the rapid movement of automobiles and tracks should be lighted so as to facilitate the identification and switching of cars.

Ore dumps or as they are sometimes termed yards or stocks are in reality stock piles to which ore is brought (from the mines) by boat or rail unloaded by various mechanical means, conveyors, grab buckets or car dumpers, and from which the ore is taken to the stock houses by ore bridges or skip hoists. Sufficient light must be provided for the operation of ore handling mechanism and the movement of cars.

In the skull cracker yards the scrap steel used in the furnace charges is broken up to suitable sizes by the dropping of a large heavy steel ball, this being handled by a magnetic lift crane controlled by an operator located in the crane cab. The scrap is also picked up and loaded in cars for transit to the furnaces and stock houses. The crane operator must be able to clearly discern the materials he is demolishing or picking up, the location of cars and the movements of ground workers.

In the Mould Yards—moulds are cleaned, stored and prepared, crane operators must be able to easily locate materials and ground

workers must have sufficient illumination for the performing of rough work.

Stock Houses are temporary storage buildings for limestone, ore, prepared scrap and materials entering into the basic manufacturing processes. Artificial light is required sufficient for car switching, the safe movement of switchmen and loaders, and the identification of materials.

In the Blast Furnaces the raw materials are reduced to pig iron. These furnaces are huge towering structures at the top of which is the charging platform reached by a steep narrow stairway. Around the lower section of the structure is located the tuyer mechanism and water jacket cooling system which are under the observation of attendants. Adjacent to the Blast Furnaces are the stoves which preheat the air blast, the blowing engine houses etc. Light should be provided to enable examination of the charging bells, safe movement along the stairways and to check the operation of the water cooling and tuyer mechanism. The areas about the stairs should be clearly visible so workers may move about promptly and safely.

At the base of the furnaces is the Cast House at which point the metal is run from the furnaces into huge ladles mounted on cars. This structure also sometimes shelters the pig casting equipment which in modern mills is of an automatic nature and receives the moulten metal, forms the pigs and conveys them to waiting cars. Workers require sufficient light for the preparation of the runways used in drawing off the metal, and operation of mud guns for sealing the furnaces after tapping etc. During actual pouring a high intensity of light is created by the moulten metal passing through the troughs to the ladle cars and casting machines.

The Open Hearth furnaces (Figure 1) receive and reduce moulten iron from the blast furnaces, scrap stock and various other materials used in manufacturing open hearth steel. They are charged both by machinery and hand. The charging floor occupies the position in front of the furnaces while the tapping pit, at which point the moulten steel is drawn off into ladles, is located at the rear. Workers are in constant attendance. Artificial light sufficient to facilitate the safe movement of workers about the constantly obstructed floors, to enable crane operators to readily locate workers and materials, and to enable the efficient handling

of ladle cars etc. is essential. The furnaces when in operation cast great flares of light over the working areas adjacent to them.

Stripping consists of the removal of the ingot moulds by means of a huge hydraulic or electric arrangement. Artificial light is required here to enable the strippers to readily engage their mechanism on the moulds and to discern the location of cars and workers. The ingots when stripped present red hot surfaces which tend to build up the illumination about the area occupied.

Mixing houses shelter huge vessels which hold, maintain at a high temperature, and mix with manganese, charges of moulten metal from the Blast Furnaces preparatory to be charged in the Bessemer Converters. Sufficient light for maintaining safety, for manipulating valves and making repairs should be provided.

The Bessemer converters are located in huge structures and are usually controlled by operators located on a shielded or enclosed platform running along the side of the building on a level with the converters. When the converters are in operation no artificial light is required adjacent to the area they occupy as they send off a terrific flare which illuminates the surroundings to intensities ranging in the hundreds of foot candles. Light should be provided however, to permit safe movement about the building when the converters are down and are undergoing repairs. Good illumination is essential on the blowers platform from which point the operation is controlled as scales and gauges must be accurately read.

The Soaking Pits are gas-heated furnaces occupying practically the entire floor area of a building set aside for them. Their covers, which are mechanically operated, occupy the principal floor surface. Their purpose is to hold the ingots at a high temperature until required by the blooming mills. Light provided here should be sufficient to enable the workers to move about with safety and to enable crane operators to easily discern the location of the floor men and pit covers. The covers when rolled back permit a huge flare to issue from the furnaces thus illuminating the surroundings to a relatively high intensity.

The Blooming Mills (Figure 2) break down the ingots to bars or slabs of a pre-determined size. The manipulation of the ingot during the process is usually controlled by skilled operators located in a pulpit above or to the side of the rolls. The white hot

FIG. 1.—A typical open hearth charging floor as it appears by night. The smoky atmosphere, the material strewn about the floor, the flare of light from the furnaces on the left, and the dark surroundings are characteristic of the conditions encountered in steel mill lighting. An intensity of two foot-candles is provided by a system of overhead units which are 500-watt Mazda C lamps in porcelain enameled bowl shaped steel reflectors. These are hung 40 feet above the floor on centers 45 x 30 feet.

FIG. 2—This modern blooming and 18 inch merchant mill is illuminated to an average intensity of 2.5 foot-candles by a well designed system of general lighting, employing 750-watt Mazda C lamps in bowl type steel reflectors on centers 40 x 50 feet, 40 feet high.

Fig. 3—Night view of a billet cleaning, chipping and inspection department. A well distributed illumination of approximately four foot candles is supplied here by the application of overhead (500-watt deep bowl units) and side (300-watt angle units) lighting. This provides working conditions well above the average encountered in this class of work.

Fig. 4—This night view of a typical hot mill building illustrates the importance of well diffused light. The installation pictured is of the better grade. Approximately 2.5 foot-candles is provided over the floor area by lamps placed 37 feet high on centers 50 x 40 feet. The Mazda C lamp and the RLM Standard dome reflector is used. The 750-watt size over the mills and the 500-watt size at the right. The rolls though appearing dark are well illuminated when the hot plates which are being reduced are passing through. The reheating furnaces will be seen at the left.

ingot after being placed on the transfer tables by a crane is caused to travel to the rolls where it is passed back and forth and turned at will by mechanical means under the control of the roll operators. The ingot being incandescent illuminates the surrounding areas during its travels causing a shifting illumination thru the mill. From the blooming mill the slab passes thru shears which trim off the rough ends and cut the slabs approximately to size. Rail mill operation is similiar to the foregoing. In Plate mills the slabs go to reheating furnaces and are then rerolled on smaller mills. Rod, Skelp and Tube mill equipment is of various forms, the rods or tubes usually being passed thru the rolls under the guidance of an attendant who grasps the rod as it emerges and snakes it back thru another set of rolls. In what are known as continuous mills the operation is more nearly automatic. Sufficient general illumination for the safe movement of workers, for the easy examination of equipment, and to permit operators to see the movement of material and indicators at all times, is essential in these areas. Supplementary lighting on roll indicators is usually practised and desirable.

Rough shearing involves the cutting of bars, billets etc. to approximate size by crop or flying shears as the stock travels along the transfer tables from the rolls.

The Chipping and Cleaning operations (Figure 3) consist of chipping out cracks and flaws in the slabs, preparatory to their being further rolled. Chipping is done by pneumatic chippers and grinders are sometimes employed for further surfacing. From the standpoint of lighting this is exacting work as fine hair line cracks and flaws must be detected, chipped or ground out by the workmen and pickling of bars and billets is also sometimes undertaken in these areas as a preliminary operation. Such work is relatively coarse however, involving as it does the preparation of vats and immersion of the material.

Sheet Mills (Figure 4) reduce slabs to sheet stock. The slabs are "pulled out" folded and rerolled several times forming sheet steel. The sheets are then trimmed or sheared and pulled apart or as it is technically termed "opened". Hot mill operators must be able to move about quickly and safely. The hot sheets illuminate the rolls mechanism during passes and the reheating furnaces assist in lighting up the areas directly before them. Opening

requires that the operator be able to easily discern the sheet edges and shearing demands sufficient illumination for accurate setting and trimming.

Cold rolling (Figure 5) and polishing is the next process in sheet making and consists of the passing of cold sheets thru high speed rolls. Cold rolling of strip is much the same and involves careful machine setting, micrometer reading and close watching of machines. In cold rolling no light is provided by the metal and good illumination is essential for the setting and operation of rolls, the reading of gauges and the promotion of safety. The sheet metal is treacherous, at best presenting exceedingly sharp cutting edges which frequently cause serious accidents when not readily visible.

Pickling consists in the running of the sheet in chemicals for the purpose of cleaning. Sufficient light for the safe movement of workers and handling of sheet is required in this operation.

The Annealing Process (Figure 6) consists of stacking the pickled sheets in large retorts which are then rolled into gas heated annealing furnaces. This is comparatively coarse work and the principal demand for light is to facilitate the movements of cranes and workers—and the safe handling of the sheets.

Tinning, galvanizing and dusting are finishing treatments of sheet steel. The vats and machines are usually lined in rows along the sides of the buildings and are under the constant attention of operators. A fairly high intensity of well diffused light is necessary over the equipment, so that setting, operation and finish can be readily observed by the attendants.

Tin Plate sorting and inspection is usually done by women workers on long benches in buildings especially set aside for the operation. The stacks of finished sheets are received on the benches, and the operators lift each sheet, examine each side and grade it in one of three classes with respect to the nature of the finish. The sheets have highly polished surfaces and are likely to cause objectionable specular reflections if the lighting is not carefully planned. This is undoubtedly the most exacting work in sheet mill operation. Flaws, scratches and surface blemishes must be easily and rapidly detected.

Wire drawing, pipe threading and nail making are semi-automatic operations. Supervision and setting of machines necessitates comparatively close work and one operator usually cares

FIG. 5—In the cold rolling department there is no luminous metal. Artificial light must provide illumination on the rolls as well as around them. In this modern steel mill an average intensity of four foot-candles is furnished by the overhead 750-watt dome and side 300-watt angle type units.

FIG. 6—The annealing department as typified in this picture offers no real difficulties from the lighting standpoint. The work is comparatively course and the light sand used adds materially in light reflection. The department illustrated is illuminated to an average intensity of over two foot-candles by 750-watt Mazda C lamps in RLM Standard dome reflectors. The building is 50 feet wide and a single row of outlets on 50-foot centers is to be noted 36 feet above the floor.

Fig. 7—A combination of general and local lighting is provided in this opening and shear building of one of the progressive sheet mills. 300-watt RLM units, uniformly distributed, provide general illumination of 2.5 foot-candles, while 200-watt local lights provide a higher intensity of 12.5 foot-candles at the shears.

Fig. 8.—Night view of a well illuminated black sheet warehouse and shipping building. An average intensity of 3.5 foot-candles is provided here by 500-watt Mazda C lamps and RLM Standard dome reflectors on approximately 35-foot centers. The illumination is quite satisfactory for the work involved.

for a battery of units. This work may be considered analogous to medium machine shop practice.

Steel mill machine shop practice usually involves a medium grade of work such as roll turning, equipment repairs etc. Visual requirements are the same as commonly encountered in this trade.

The power houses and substations represent the heart of the plant and such illumination as will facilitate inspection, cleanliness and safety is essential.

The Cooling Tables as the name implies are huge steel platforms on which the metal from various rolling processes travels for cooling. These tables are also quite frequently the point of inspection. Illumination must be adequate for observing the operation of the shifting fingers (frequently painted white to increase the visibility) which move the materials and for the inspection and making of the stock. Inspection is sometimes done by operators who draw a piece of wood along the hot stock, the examinations being made by the light of the resultant flare.

It is believed that the use of the visual demands within other areas is obvious and no further discussion regarding them is required here.

PRESENT PRACTICE

In every mill inspected, incandescent electric lamps exclusively were being used for the lighting of all areas. In all cases general illumination of some form was provided, either alone or in combination with localized lighting on particular operations.

Lamps employed for general illumination usually ranged from the 300- to 1000-watt size, the larger units predominating. Localized units commonly made use of lamps of sizes of 200 watts and below. Reflectors of some type were invariably found to be used with the lamps employed for general lighting.

Those observed were of various types, the RLM Standard Dome, flat enamel steel, shallow dome, deep bowl and angle type porcelain enameled steel being common. While the flat enameled steel and shallow dome reflectors were predominating in the older installation, the RLM Standard Dome and Deep Bowl Enameled Steel seem to represent modern practice.

The local lighting was usually found to be not so well provided for. A very nondescript collection of reflectors and bare lamps creating objectionable glare was common.

Spacings of units, in most instances, were found to be much wider than practicable for the provision of uniform light distribution.

While the importance of periodic cleaning of lighting equipment was found to be universally admitted, but few of the mills visited practiced regular maintenance schedules. This situation was usually explained by the difficulty experienced in obtaining suitable labor.

With but two exceptions, the plants investigated were found to be using 250 volt nominal lighting service with either 250 volt lamps or two 125 volt lamps in series. The lighting circuits in many cases were tapped direct from the power feeders supplying the auxiliary drive within the building to be lighted. The disadvantage of operating two lamps in series and superiority of 110 volt (or thereabout) lamps for general lighting service are too well known to require discussion here. The practice of operating lighting circuits from d-c. power feeders, particularly in steel mills, is extremely objectionable as severe voltage fluctuation is prevalent due to the constantly changing load on the generators. This results in bad flickering of the lights and of course affects the life and light output of the lamps. In one mill visited by the writer a variation of almost 2 to 1 in intensity was noticed at times. Figure 10 shows a voltage chart taken across the bus bars in a typical steel mill substation. From this chart it will be noted that a variation of 240 to 315 volts occurred over the period of observation which means that neglecting a slightly variable line drop the lamp voltage varied in the same proportion.

Separate lighting circuits, or in the case of a-c. drive mills, high voltage distribution with a step down thru transformers and buck and boost regulators where voltage variation is extreme are best adapted to the producing of satisfactory mill lighting. In many cases schemes of this kind are in the course of installation or under consideration.

THE TREND IN LIGHTING PRACTICE DURING THE PAST TWELVE YEARS

Table II following, gives the prevailing intensities in certain areas of typical steel mills in 1911 as found by an investigation

FIG. 9.—Night view of a well illuminated bar storage warehouse. The intensity, 2.5 foot-candles, provided here is adequate for stacking and loading. A higher intensity is provided for the machines visible at the rear end by using 500—rather than 300-watt lamps.

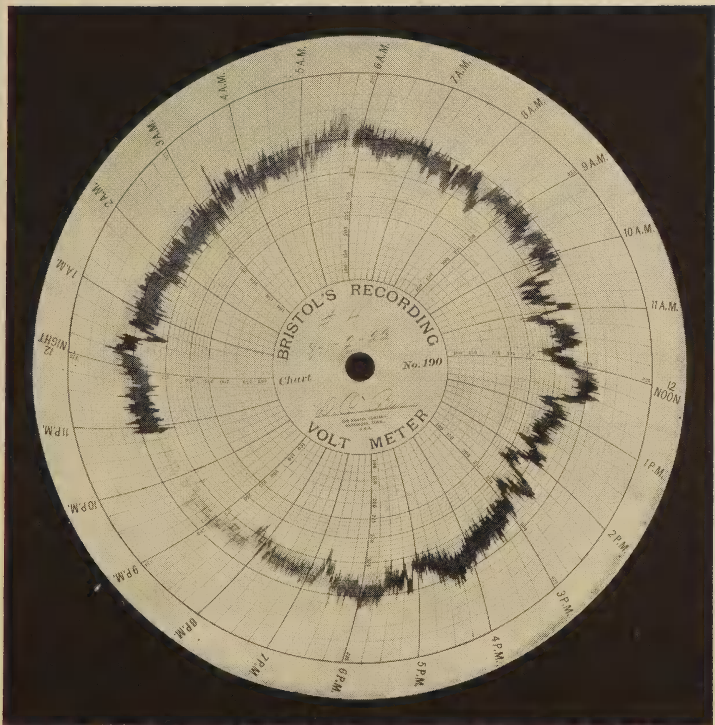


FIG. 10.—Reproduction of a typical d-c. bus voltage chart, illustrating the widely varying voltage conditions existing on d-c. power feeders.

FIG. 11.—Night view a of well lighted foundry. 300-watt Mazda C lamps in RLM Standard dome reflectors on centers 10 x 40 feet are mounted on the ceiling trusses, 35 feet above the floor. An intensity of over five foot-candles is provided.

FIG. 12.—This picture of a typical foundry gives one a good idea of the rough footing and generally hazardous conditions encountered in this industry. A number of 300-watt Mazda C lamps in RLM Standard dome reflectors on 10-foot centers in this 40-foot bay provide adequate light (five foot-candles) to make objects clearly visible and minimize accident hazards.

conducted at that time, and figures obtained by the author on the extremes good and bad constituting present practice.

Process or Area	Intensity—1911 Foot-Candle Average	Intensity—1923 Foot-Candle Average Low	Intensity—1923 Foot-Candle Average High	Intensity Foot-Candle Recommended
Thoroughfares	0.087	0.02	0.3	0.1 – 0.5
Ore Yards	0.19	0.2	0.3	
Loading Yards (No Inspection)	0.14	0.2	0.4	0.25– 1.0
Loading Yards (Inspection)	0.36	0.5	0.75	
Open Hearth Mould Yards	0.29	0.2	0.4	
Stock Houses	—	—	—	0.5 – 1.0
Open Hearth Charging Floor	0.14	0.3	1.5	1.0 – 2.0
Open Hearth Casting Floor	0.17	0.5	1.5	
Soaking Pits	—	0.15	1.5	1.0 – 2.0
Reheating Furnaces	0.46	0.3	3.	2.0 – 4.0
Puddling Furnaces	—	—	—	2.0 – 4.0
Annealing Furnaces	—	0.5	3.5	2.0 – 4.0
Blast Furnaces	0.25	0.4	0.7	1.0 – 2.0
Cast Houses	0.22	0.5	1.	1.0 – 2.0
Mixing Houses	—	—	—	2.0 – 4.0
Bessemer Converter Houses / Bessemer Blowers Platform	—	2.5	4	3.0 – 6.0
Ingot Stripping	—	0.4	1	1.0 – 2.0
Blooming Mills	0.32	0.5	2	2.0 – 4.0
Cooling Tables	—	—	—	2.0 – 4.0
Rail & Structural Mills	—	0.5	2	2.0 – 4.0
Pipe & Tube Mills	0.3	0.5	1.5	2.0 – 4.0
Chipping	—	3.5	7	4.0 – 8.0
Hot Mills	0.34	0.75	3.5	2.0 – 4.0
Cold Rolling	0.65	1.5	5	4.0 – 8.0
Shearing (Close)	—	1.5	11	8.0 –12.0
Inspection (General)	—	—	—	4.0 – 8.0
Wire Drawing	0.87	1.	3	4.0 – 8.0
Pipe Threading	0.76	1.5	5	4.0 – 8.0
Nail Making	—	—	—	4.0 – 8.0
Pickling	—	0.25	1	2.0 – 4.0
Tinning	—	1.5	5	4.0 – 8.0
Tin Plate Sorting & Inspecting	—	5	12	10.0–15.0
Warehouses	—	1	2.5	2.0 – 4.0
Shipping	—	1.5	3	3.0 – 6.0
Machine Shops	1.37	2.5	4	4.0 – 8.0
Power Houses	1.13	2.5	6	4.0 – 8.0
Layout & Fabrication (Structural Steel)	—	—	—	4.0 – 8.0

Because of the wide variation in existing practice it was considered desirable to average the high and low readings separately citing each rather than quote a common average.

A careful study of manufacturing requirements and conditions has led the author to the conclusion that the intensities listed in the fourth column are economically desirable in mill lighting.

Consideration of these figures clearly illustrates that there has been a distinct trend toward higher intensities in the lighting of steel mills during the past twelve years, as with but few exceptions, the average low values of today are well above the average in 1911 while the average high values in all cases represent a marked increase.

In only three of the plants investigated however, were lighting values of the higher order found to exist generally, which fact combined with the radical departure between high and low averages, would seem to indicate that there has not been a full appreciation of the value of good lighting and there is still room for marked improvement in the lighting standards of the industry as a whole. It should here be noted that the mills having the higher intensities were all of relatively new construction having been built within the last six years whereas the others were considerably older. This in a measure explains the variation in values.

It is interesting to note the comparative attitude of the operating engineers responsible for lighting practice in mills having good and poor lighting. In the case of the better installations it was invariably expressed that good lighting had proven beneficial from the standpoints of safety, supervision and elevation of morale, in operations on hot metals and as an aid toward greater production and reduction in spoilage plus the aforementioned benefits in the case of processing of cold metal. In one mill an instance was cited of two buildings both housing hot sheet rolling operations one well lighted and the other poorly lighted. When operators were transferred from the well lighted to the poorly lighted building they objected so strenuously to the gloomy, forbidding and hazardous surroundings that the remodeling of the lighting equipment was practically forced.

On the other hand the operating engineers in the poorly lighted mills, while considering the necessity for artificial light in some form, usually looked upon it as being a consideration of secondary

importance. Installation in most of these cases are a result of individual opinion and past practice within the mill. Often a guess is made as to how much light is needed, this is provided, and as long as no complaints are registered by the workers the illumination is considered satisfactory. It should be obvious that such practice is far from commendable and it is questionable whether the workers as individuals are capable of judging the suitability of lighting standards. Most workers are faced with a lack of knowledge of any conditions other than those beneath which they work and as a consequence are easily satisfied with the conditions at hand. That they would favor better lighting is indicated by the instance previously cited.

The opinion seems to prevail that in most areas it is necessary to simply furnish enough light to find one's way about and that the hot metals and furnaces will furnish enough illumination for closer work.

A careful consideration of the problem of steel mill lighting leads to the conclusion that while one of the prime functions of artificial light within and without the mills is to promote safety, this factor is somewhat more involved than would seem the case on hasty consideration and further there are other benefits to be derived from the proper application of light.

The visibility of objects in steel mills is inherently low because of the characteristically dark surroundings and dark nature of the objects themselves. Since we see objects by the light they reflect to the eye it follows that to easily distinguish dark objects requires more illumination than if they were light in color. Largely for these reasons the steel industry requires more illumination from the safety standpoint than do most other trades.

The hot metals worked, while unquestionably instrumental in building up the lighting at the working points, are present only at intermittent periods and are constantly moved from place to place. This condition creates a demand for more rather than less light. The incandescent metal represents sources of high brilliancy within the worker's field of view. If the adjoining areas are dark the eye does not see clearly as it moves to the dark surroundings from the bright work and vice versa. The wider the contrast in intensities the greater the degree of readjusting and the longer the time required by the eye to adapt itself as it moves about.

Mention has already been made of the abnormal amount of foreign material present in the atmosphere, hence to overcome the resultant absorption a relatively high wattage for a given area is necessary to produce the desired intensity on the work.

Moreover, even with frequent cleaning, depreciation of reflecting surfaces is a factor which must always be given careful consideration and adequate provision made to insure a satisfactory average value of illumination.

Production increases through speedier movements on the part of the workers, cleaner surroundings and easier supervision of labor, derivitives of good lighting often discussed in the past, are also made possible in many areas of the steel mill.

FOUNDRY LIGHTING

In view of the close relation between the modern foundry and the Iron & Steel Industry as herein discussed it is felt that a brief consideration of Foundry Lighting practice is appropriate at this point.

FLOOR MOULDING AND POURING

Inasmuch as both of these operations are carried on within the same area though at different times of the day the lighting system will be the same. Moulding calls for the greatest accuracy and is usually done during the early hours of the day. For pouring and stripping the lighting demands are less exacting. This work is carried on during the latter part of the day when natural light is poor and the air in the foundry is full of dust and gases. However, if provision is made for proper light for moulding, a lower though adequate intensity will automatically prevail for pouring and stripping. The intensity employed should range from 4 to 12 foot-candles depending upon the character of the product. For the manufacturing of heavy castings where the finish of the mould is not important intensities of from 4 to 6 foot-candles are sufficient. In foundries casting small parts requiring careful finish and consequently closer discrimination of detail from 6 to 12 foot-candles should be provided.

BENCH MOULDING, MACHINE MOULDING AND CORE MAKING

The lighting of this type of work, which calls for some discrimination of detail since the pieces turned out are usually small

and must be accurately moulded, can best be accomplished by what is termed a "localized general" system. A high intensity is required along the row of machines or benches while a lower illumination is sufficient for the remainder of the room. This effect of varied intensity is obtained by placing the lighting units relative to the machines. The maximum intensity is thus delivered from the correct direction and the spread of light takes care of the surrounding areas. Such a system has practically all the advantages of the drop light in getting the light where it is needed and yet the lighting units are not within reach.

CHARGING TUMBLING AND CLEANING

The work coming under the above classification is of a relatively rough nature and requires little discrimination of detail. Intensities of from 3 to 6 foot-candles are adequate. Distribution should be such that harsh shadows and dark corners will not result and hatchways and pits be readily visible.

In lighting equipment as is true of practically all other devices used in steel mills permanence, simplicity, durability, efficiency and ease of maintenance are essential requirements.

Porcelain enameled steel reflectors of the RLM Standard dome variety and, in the case of buildings which are narrow compared to their height, porcelain enameled steel reflectors of the angle type mounted below the crane rail represent the best types of the reflectors available for interior lighting. For exterior lighting the RLM standard dome, the radial wave, enclosed forms of street lighting units and floodlighting units are admirably adapted.

LIGHTING COSTS

From the standpoint of energy cost the operating expense of the average steel mill lighting installation is exceedingly small in comparison with the total production cost. Although conditions vary widely in different mills the following citation serves to illustrate the relative magnitude of the lighting expense. In a typical mill the cost of energy was found to be six-tenths of one cent per kw-hr. This figure is typical, the cost usually ranging from five-tenths to seven-tenths cents. The total average energy consumption per ton of Open Hearth steel produced in the

particular mill reckoned over a period of twenty-four hours including all drives, cranes and lighting was approximately 45 kw-hr. It may be conservatively estimated in a mill of this type that the lighting load represented about 2 per cent of the total load. Since the energy consumption per ton figure is based on a typical twenty-four hour period and since in this as well as the average mill there are about 12 hours of daylight work and 12 hours of work under artificial light, the actual energy consumed per ton output under artificial light was $2 \times 0.02 \times 45 = 1.8$ kw-hr. At a cost of six-tenths cents per kw-hr. this represents a cost of light of $0.6 \times 1.8 \times 1.08$ cents. In a mill rolling sheet this figure would of course be somewhat larger but as a maximum would probably not exceed 10 cents per ton.

In the face of these figures and considering the influence of properly applied illumination in promoting safety, increasing production, reducing spoilage, elevating the morals of the workers and facilitating supervision it is difficult to excuse the low intensities so commonly encountered and easy to justify the occasional installations of good lighting.

Bibliography

Special Lighting for Steel Mills, H. M. Gassman, Proceedings, A.I. & S.E.E. 1911.

Illumination of Iron & Steel Works, C. J. Mundo, Proceedings, A.I. & S.E.E. 1911.

Some Features of Illumination of Iron & Steel Works, Ward Harrison, Proceedings A.I. & S.E.E. 1911.

Modern Illumination in the Iron & Steel Industry, C. E. Clewell, Proceedings, A.I. & S.E.E. 1912.

Incandescent Lamps in the Steel Industry, Ward Harrison, Proceedings, A.I. & S.E.E.

Steel Mill Lighting, B. G. Beck, Electrical World, Oct. 5, 1912.

A Progress Report on Illumination, Ward Harrison & B. H. Magsdick, Proceedings, A.I. & S.E.E. 1913.

The Flaming Arc Lamp in the Iron & Steel Industry, A. T. Baldwin, Proceedings, A.I. & S.E.E. 1914.

High Candle Power Mazda Lamps for Steel Mill Lighting, G. H. Stickney, Proceedings, A.I. & S.E.E. 1914.

Lighting of Steel Mills with Quartz Lamps, G. C. Keech, Electrical Review, Sept., 1916.

Illumination Iron & Steel Mills, C. E. Clewell, Electrical World, July 21, 1917.

Better Lighting of Iron & Steel Mills & Fabricating Plants, F. H. Bernhard, Electrical Review, Nov. 30, 1918.

Practical Methods in Lighting of Steel Mills, D. E. Atwater and J. J. McLaughlin, Electrical Journal, Sept., 1922.

Lighting a Large Iron Foundry, G. H. Stickney, American Machinist, Dec. 1, 1910.

The Efficient Lighting of Foundries, B. G. Worth, Castings, April, 1912.

Lighting for Core Room of Foundry, R. S. Rich, Electrical World, April 16, 1921.

Foundry Lighting, J. M. Shute, Industrial Engineer, April, 1922.

DISCUSSION

F. C. Caldwell: In drawing up the Industrial Lighting Code for Ohio the only concerted opposition we experienced was from the steel industries of the state. The explanation for this I think is found in two conditions; one has been mentioned in the paper, that is, that the steel manufactures have always been used to doing their work by the light of the hot metal, and it is hard for them to feel that any more light is needed than that which has been used for generations.

Again, the steel industry is one of the oldest industries and in general we find that the older an industry, the more conservative it is. For instance, the rubber industry is one of the youngest, at least in its present state, and that was the industry from which we received the most cooperation. They looked most favorably upon the movement for better lighting in industry.

These two characteristics of the steel manufacturer must be overcome before a general improvement in steel mill lighting can be attained.

J. A. Hoeveler: When I began my work for the Industrial Commission of Wisconsin, I came across the argument several times that Professor Caldwell has mentioned; namely: that the hot metal in the foundry or mill would provide sufficient illumination, with some small amount of supplementary artificial lighting. But it was not until some time ago that I heard the prize argument against higher illumination, when, in talking to the night superintendent of a factory, after we had measured the illumina-

tion and found it to be of very low order, the man replied, "Well, you know, I wouldn't want more illumination in this factory; I am afraid if it were too bright it would put my men to sleep."

H. W. Desaix: I believe that in the last few years there has been a marked difference among the steel people, but I note that the paper omits one phase of the steel industry, that of the concentrating mill.

Iron ore today is not sold in the crude form that it used to be. It is concentrated to a high value and the premium on the ore is based upon the value of it; that is, the percentage of iron.

You perhaps all know that when a man is buying raw material he endeavors to get it at as low a cost as possible, and that creates a condition of high competition among the concentrating mills.

There has been within the last few years considerable development in the concentrating mills. They have raised their amount of production and decreased their cost of production by automatic machinery, use of magnetic separators, magnetic clutches and the like. I have in mind a particular concentrating mill that used to turn out 1500 to 2,000 tons of ore a day, using 18 men within the mill; due to the use of automatic machinery they have reduced the number of men employed within the mill to 5—that means number of men per shift.

As soon as they did this however they came across a condition that caused them a considerable amount of trouble—that of tramp iron. Tramp iron would get into escalators and crushers and sometimes cause damage. Lighting intensities were therefore considerably increased so as to allow these few men in the mill to pick up the tramp iron and push the buttons which are used to release the magnetic clutches and stop the operation long enough to pick out the tramp iron.

I know that in northern New Jersey there is a considerable field right now for higher intensities of illumination in the steel industry; of course, there we get the mining end of it and not the production end.

F. W. Loomis: Have had no specific experiences with the iron and steel industry since I have been located in Pittsburgh but can cite something of a parallel nature in Canada; it is with regard to another metal—aluminum.

I had the privilege of visiting a plant in Quebec Province about eight months ago and I do not believe they even attempted to guess at intensities because when I went around with the superintendent to check the intensities as found, in one process that might be called medium fine at least—that is, changing rods to tubes—I checked about a quarter to one-half of one foot-candle. That was about as high as anything that was discovered in the plant. From this investigation, the superintendent decided to take definite steps to build up his intensities. He was sold on the idea of what higher standard illumination really means from the standpoint of production.

The reflectors found there were of an old type aluminum finish, and the fumes from the plant had so deteriorated them that they were worthless. I recommended something that could be more easily cleaned, and I believe that recommendation had been acted upon.

This would imply that the iron and steel industry and the metal industry as a whole are receptive to our suggestions if same are brought to their attention. It is perhaps sometimes quite a job to make them accept higher intensities but the field undoubtedly is awaiting us.

In the Pittsburgh district I understand something has been done toward increasing or attempting to increase the illumination standards but there is still a wonderful field awaiting us.

Thomas G. Ward: I would like to ask on the matter of cost, if the hourly demand was taken into consideration on that in figuring the lighting and diversity factor, which would materially lower that cost factor.

A. S. Turner, Jr.: Mr. Rademacher's calculations of the lighting cost have all been figured with a considerable factor of safety, so that no steel mill engineer might state that his figures were lower than was actually the case. This would cover any discrepancies which might arise in the various processes of manufacture.

G. H. Stickney: My recent experience in steel mill lighting comes second-handed through Mr. Rademacher, so that I have not a great deal to add regarding present practice. I have been over Mr. Rademacher's work quite carefully and have considerable confidence in the conclusions which he has reached.

My most careful study in steel mill lighting was made about 1909 or 1910. At that time we succeeded in pointing out to the mill engineers the importance of better lighting. Our investigations showed that some mills were using something like ten times as much light for certain processes as were others. These comparisons called to the attention of the mill people, resulted in a considerable advance in the average practice, as referred to by Mr. Rademacher.

There has been a certain amount of advance since 1910, but I believe the practice is still far below what economic conditions would warrant. Steel making is a night and day process, requiring men to work for long hours by artificial light. Hence the advantages to be gained through enhanced safety and increased production are relatively large. Furthermore, fortunate circumstances provide steel mills with remarkably low price power, so that the cost of good illumination is comparatively small.

The failure to provide better lighting does not appear to be due to its cost, but rather the fact that those responsible for the lighting have many other complicated engineering problems, involving large expenditures, and this has a tendency to divert their attention so that lighting does not have the consideration which it really needs.

Due to the liability of mechanical accidents, many of the processes of steel making are quite dangerous, so that it is important that the steel industry should recognize that good illumination is one of the most important agencies for preventing accidents, and furthermore, that it is the one guard which speeds production rather than retards it.

O. F. HAAS: I would like to ask Mr. Turner if in the plants visited the exterior lighting in the main consisted of flood-lighting or general overhead lighting using enameled steel reflectors or refractor units.

A. S. TURNER, JR.: The equipment now being used in steel mill yards consists, in a small degree, of that employed for street lighting, such as prismatic refractors. The majority of this lighting is merely the incandescent lamp with radial wave reflectors or plain porcelain enamel steel reflectors.

WALTER STURROCK: As shown by this paper, the levels of illumination in steel plants in general are found to be quite low. About two years ago, one of the steel plants that I visited had an intensity of illumination of only about a half foot-candle. I talked with the electrician about the value of better lighting in steel mills and soon afterwards he began studying lighting from the standpoint of accident prevention. He was particularly interested to find out just what he could do to improve the conditions so that his plant would be a safe and better place to work.

As a result of his study as to the value of better lighting he planned the lighting system for a new building which they were adding to their plant. In this new building he installed 1,000-watt lamps on 20 x 20 foot centers, producing a level of illumination of about 18 foot-candles. He later reported that this level of illumination was very highly appraised by the executives of his plant.

I think this illustrates the favorable attitudes which many electricians would take toward better illumination in steel mills, if they would more carefully study the value of higher levels.

I would like to ask Mr. Turner in connection with this paper if he knows how many plants were visited.

A. S. TURNER, JR.: Twelve, I believe, in all.

HOSPITAL OPERATING ROOM LIGHTING WITH REPRODUCED DAYLIGHT*

BY NORMAN MACBETH**

SYNOPSIS: The hospital operating room is probably one of the most important fields for artificial illumination, a human life may depend upon what the surgeon does not see. Daylight color for the proper identification of the various tissues is of extreme importance. During the operating period—throughout the year, with a minimum in the heated summer months—the natural daylight is frequently inadequate due to dark days, storm clouds and the shortened period between dawn and sunset.

A description is here given of an artificial daylighting equipment furnishing a light of daylight color with the mechanical arrangements in two operating rooms where the demands of the surgeons have been satisfactorily met.

The intensities throughout the operating table zone generally run from 50 to over 65 foot-candles with current densitites of 12 and 16 KW per room. The light is multidirectional towards the center of the room; a scheme of localized general illumination. The shadows are softened and are illuminated to an extent just less than the high lights.

None of this equipment is below the ceiling and none of it is directly over the table thus removing the dust and radiant heat objections present with the usual table operating luminaire.

In a recently published article by an experienced investigator, the statement was made that in an inspection tour through over one hundred hospitals located in the East only two had lighting equipment of comparatively modern type—artificial illumination having received practically no attention—the fixtures and methods of lighting being those prevailing in the early days of electric lighting; while the latest in instruments, sterilizing apparatus—operating and antiseptic devices were in use; the lighting equipment almost without exception was on a par with the type of sterilizing apparatus which would be represented by a wash boiler and a gas burner.

In no other class of buildings, particularly in the operating rooms, are the lighting requirements so exacting. Probably in no other profession is the ability to see quickly and truthfully as important as in surgery where a human life is at stake.

The location of operating rooms on upper floors with liberal window and skylight exposures results in a high standard of illumination with which the customary artificial lighting intensities suffer by comparison. Artificial light as a consequence has been largely used for emergencies and for cleaning up purposes, and because of the almost universal belief that artificial light is expensive and daylight cheap, but slight effort has, in the past, been made to build up the illumination to the necessary high intensities.

*A paper presented before the New York Section of the Illuminating Engineering Society, April 19, 1923.

**Illuminating Engineer, Macbeth Daylighting Co., New York, N. Y.

Photometers have been but comparatively recently used by electrical engineers and hence it is only within a few years that it has been realized that the intensity of artificial light generally supplied was so far below that available in the well designed operating room on clear days. There has also been a failure to appreciate the considerable importance of color of light in its effect on the color of objects viewed under it.

Low hung fixtures directly over the operating table have also caused difficulty because of radiant heat. One surgeon recently described the equipment in his operating room as "an inverted bath tub full of hot glaring incandescent filament bulbs", which during an operation necessitated the constant attention of one nurse to wipe the perspiration from the faces of the operating surgeon and his assistants.

These typical bath-tub fixtures were not always sanitary, they collect dust, and the light distribution, when highly concentrated, was generally productive of dense shadows.

At all times the color of artificial light has differed so widely from that of natural daylight that tissues, blue veins, arteries, bile ducts and so forth were seen with extreme difficulty, if at all. Artificial light as most frequently used has failed on many counts but particularly in color, intensity and distribution. Shadows should be softened—they should not be in absolute darkness nor yet eliminated through perfect diffusion of light, with as high intensities of illumination on those surfaces where shadows are natural as on the highly lighted parts. An absolutely uniform illumination of all surfaces whether horizontal, inclined or vertical would be nearly as unsatisfactory as the other more usual extreme of high lights and dense shadows.

Nor has natural daylight been wholly ideal—it has only been comparatively better. It is not uniform in intensity throughout the day nor throughout the year. Even on equally clear days the intensities between summer and winter vary tremendously.

With cloudy days to contend with even natural daylight from day to day is none too good—at its worst it is quite as inadequate as has been the average artificial lighting equipment.

Because of the necessity for quick accurate vision natural daylight therefore has only partially met the situation—met it only on clear bright days and for a limited number of hours per day. This

quality of daylight is exceedingly limited during many months of the year and in some localities, in cities and towns adjacent to the Great Lakes, the percentage of cloudy or not clear days is well over 50 per cent throughout the year—by far the greater number of clear days coming in the summer when the operating rooms are in less constant use because of vacation periods and the putting over of many operations to evade hot weather.

To adequately illuminate operating rooms with an electric daylight merely required a photometric study of operating rooms under satisfactory conditions of natural daylight illumination, and a working back to designs in lamps adapted to the reproduction of daylight, to enable plans to be worked out which would result in the proper illumination of an operating room. Dependence for the final approval of the result was left to the judgment of the operating surgeons.

Operating room lighting with the equipment used in these rooms is therefore not an experiment—nor is it particularly new—it is just an engineering adaptation, fitted to the operating room, of the equipment used in other fields during the past seven years. It has done more, however, than to just illuminate an operating room for emergencies, for late afternoons and exceptionally cloudy days. It is represented as an improvement over all but the few best natural daylight hours of the year in operating rooms equipped with more than the usual glass window and skylight areas. It has proven to be a system of lighting so adequate that operating rooms may be located with a view only to their convenience—no longer is it necessary to go to the top floor of the building.

An operating room with this system of lighting may be located in the basement just as satisfactorily if from the standpoint of convenience that location would be desirable.

So far as the eye can judge, and the operating surgeons' opinions taken, it is natural daylight duplicated or reproduced as to color, distribution, and the necessary intensity, and in addition is available at any hour from any electric service on which standard incandescent electric lamps can be used; direct or alternating current and voltages—110 to 125, and 220 to 250 volts.

A light permitting exact, accurate color discrimination and freedom from the usual dust collecting intense heat-radiating lighting fixture over the operating table—a lighting effect similar

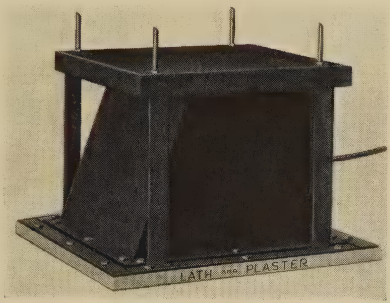


FIG. 1.—Exterior view of Macbeth Daylight Lamp No. WD1co showing provision for ventilation, the suspension rods and the method of attachment to the ceiling.

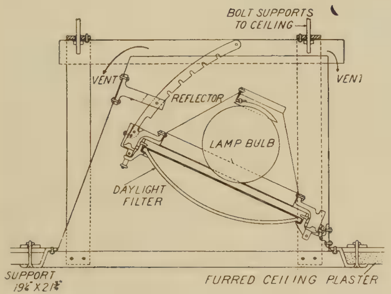


FIG. 2a.—Sectional view of Lamp. Lamp and reflector unit is adjustable as to maximum light distribution from vertically downward to 35° from the vertical, towards center of room. The final adjustment is dependent upon the size of room and the height of the ceiling. The procelain lamp socket used is also readily adjustable to properly center the filaments of the 500 watt or 1000 watt flood lighting bulbs for which this equipment is designed.

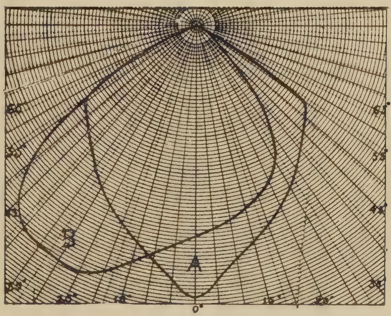
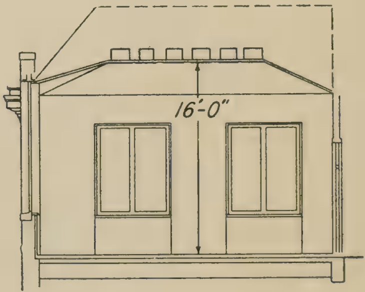


FIG. 2b.—Characteristic Distribution of Light. Fom Daylight Ceiling Lamp (Fig. 1). "A" Parallel with bulb axis. "B" Normal to bulb axis and directed towards center of room.

FIG. 3.—Natural Daylight. The admitted ideal on days when daylight of good quality is avaliable. Operating Room, Women's Clinic Building, Johns Hopkins Hospital, Baltimore, Md.

North Window 10 ft. high by 8 ft. wide, "hammered" glass. Floor, green tile. Sidewall, to 60 in. height—green tile. Room 24 ft. by 25 ft. Ceiling height, 16 ft.



to that of an all glass ceiling with a clear sky continuously overhead.

In planning the installations here illustrated the hospital authorities emphasized, first,—the necessity of furnishing a high intensity of illumination; second,—a diffusion of light which would result in softened shadows—that is, illumination in the shadows; third,—the importance of keeping all lighting equipment away from the region over the operating table, thus eliminating the dust and heat hazards; and fourth,—an arrangement of lamps, screened in such a manner as to eliminate the glare factor.

Glare is objectionable because of those retinal burns resulting in more or less persistent after images which for an interval, long or short depending upon the exposure and the adaptation of the eye, blurr the vision. This is an almost instantaneous result of exposing the normal eye, even for a flash view, to the over bright filaments of our present high efficiency, high temperature concentrated filament light sources. The glare possibilities lie in that zone above the critical angle of 60° from the vertical. The type of lamps used in these installations has a sharp cut off at 55° from the vertical,—a more than 5° safety factor.

This system of daylighting equipment has been developed during the past seven years for many specific uses in industrial, textile and mercantile fields where a demand existed for seeing colored objects and materials as they appear in good natural daylight. To enable exacting inspection and critical examination processes to be carried through on dark days and at night with results equal to the best natural daylight hours, and without the customary eye fatigue associated with artificial light.

The reproduced daylight from these lamps or lighting equipment is from ordinary clear glass Mazda or tungsten filament bulbs the light from which is corrected by passing through a special light filter so that it is modified in quality to be the same as natural daylight in its effect on colors. It is not loosely described as an "approximate daylight" nor as a light approximating the quality of sunlight nor of any particular daylight. So far as the eye and color are concerned it is daylight. That this effect has been secured has been vouched for during over seven years of practical every day use by hundreds of color experts checking against good natural daylight with thousands of colors, shades and hues in all kinds of fabrics and materials.

This system should not be confused with the various arrangements of ordinary blue glass lamp blubs. While these blue bulbs have been called "daylight lamps" by the lamp manufacturers it is generally known that this is regarded by them as a convenient commercial designation and is not a claim for technical accuracy. The fact is that the color of light with these blue-green bulbs lies on a light-color scale about midway between that from the ordinary clear glass lamp and the direct light of the sun at noon in the summer. This light is therefore, owing to its midway position, as close an approximation to ordinary artificial light as it is to sunlight.

All workers in color know that observations in direct sunlight are misleading and of little value in color identification, and they appreciate also that there is a wider difference between the color of light from a north sky exposure and direct sunlight than there is between sunlight and ordinary artificial light.

The filters used are solid glass with the color in the glass appearing dark blue by daylight and clear and colorless by transmitted artificial light. They need only be kept clean by an occasional washing and used with standard clear glass incandescent electric bulbs of the proper size and voltage rating.

If taken in time, when planning new buildings and credited with window and skylight construction costs which may be saved the total cost of this lighting equipment is exceedingly moderate.

Much depends upon the size of the rooms and particularly upon the height of the ceilings, which largely determine the number of lamps to use.

The maintenance costs—for bulb replacement and electrical energy are of course greater than for the present admittedly inadequate luminaries. These costs depend largely on the costs of the electric service and in terms of other equally important costs have been shown to be comparatively insignificant. They may run as high as fifty cents to a dollar per hour's use—a total cost most nearly comparable with that for gauze and bandages or a small percentage of the operating room charge or a lesser percentage of the standby charges for surgeons and attendants during an operation.

The relatively higher intensity of light on the operating table shown in Figure 4 resulted in an over-exposure of the photographic negative at this point. The intensity of light on a horizontal plane

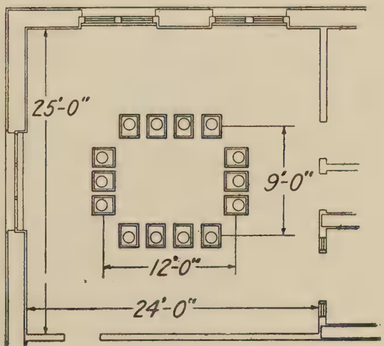


FIG. 4.—Electric Daylight, Johns Hopkins Hospital.

Fourteen Macbeth Daylight Ceiling Lamps (Fig. 1), with 1000-watt clear glass bulbs and Southern overcast-sky equivalent daylight filters, arranged in a rectangle on 9 ft. by 12-ft. centers.

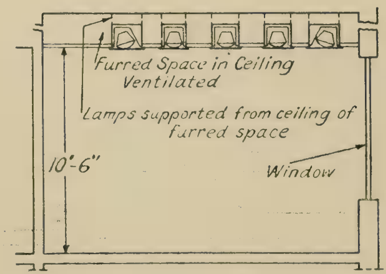


FIG. 5. Natural Daylight. Operating Room. Boston Lying-In Hospital, Boston, Mass.

Window 8 ft. wide extending to ceiling. Room, 14 ft. by 16 ft. Ceiling height 10 ft. 6 in.

"Shadowless daylight" as shown here is a phrase that cannot be applied to the light distribution received even from this large window with northern exposure.

36 inches high and over the area extending radially more than 5 feet from the center of the room, that is over a 10 foot circle, ran above 55 foot-candles. This intensity was appreciably greater than that secured at noon on a clear day with natural daylight.

The artificial light has the additional advantage in being directed from four sides, equally illuminating vertical and oblique surfaces where with natural daylight, owing to the window locations, the surfaces facing the windows were highly illuminated with somewhat dense shadows on the other two sides.

The negatives of both operating rooms are without retouching and the prints are free of art work. Just plain photographic comparisons by local disinterested photographers, using exclusively of course the sources of light shown in each illustration.

In the illustrations of the Boston installation, Figures 5 and 6, the photographer used particular care to give both exposures equal time, with the same lens stop, same kind of plates, equal development, etc.

The curtains shown on the windows were fitted shortly after the electric daylighting was used. Visibility conditions were found to be much better when the view of the sky and the varying intensity of the natural daylight due to the alternating clear sky, light and dark clouds, were shut out.

At night the curtains reflect into the room that light which would otherwise be lost by transmission through the window glass.

Photometric measurements in the Boston room, Figure 6, showed an average of over 65 foot-candles on the 36-inch horizontal plane, uniform over a ten foot circle. Compared to the results in Figure 5 with natural daylight, the artificial light intensities were higher at all points beyond two feet from the window and from the center of the room to the wall opposite the window, the intensities were from three to seven times those of the natural daylight. The artificial light was appreciably more uniform while retaining, of course, all the color advantage of natural daylight.

Of course there have been objections raised to this system, relatively few by those who have seen either of these two installations; our chief difficulty is with those who are color blind either wholly or partially and with the greater number who are actually unaware of the enormous difference in color between ordinary

artificial light and daylight. They apparently have no appreciation of the unseen detail under artificial light and the visual possibilities of daylight; and particularly of the advantage of intensities of over fifty foot-candles even with objects or materials having high reflection factors. It has long been my conclusion that much of the going to the window or the store door to see what a fabric looked like was not so much because of color but for the detail revealing high intensity daylight, which would help out the sense of touch with that of sight—to see whether a material was pressed hair, woven wool or matted cotton fiber.

The effective filtered lumens per watt on a photometric basis from this equipment will probably not exceed five and may in some instances be as low as two. This is not due to an inefficient filter any more than a wire screen which would only pass sand and gravel not exceeding the size desired would be inefficient if it passed practically all of the size for which it was designed and none larger.

This subtraction method of correcting the light from Madaz lamps necessitates considerable absorption in the red, orange and yellow to even up this part of the spectrum with the violet and blue proportions in the light of the tungsten lamp wherein it differs from visual daylight. To return to the screen and sand, what would you do if desiring sand and gravel not exceeding that size which would pass a one quarter inch mesh if you found the laborer after shovelling ten cubic yards of gravel against the screen had secured only one or two cubic yards of the desired size—a three-eights or half inch screen wouldn't be considered more efficient as it would probably pass too much of sizes above that desired—you wouldn't blame the screen but the sand pit and you would probably advise your laborer to select a part of the pit further removed from the boulder size and ring more into the desired sand and gravel size. The tungsten lamp is our gravel pit—if we have to sift or filter out a considerable quantity of the total flux it is because of the large proportion of long wave lengths compared to the much lesser proportion of shorter wave lengths in the visible spectrum of that lamp—but don't charge the filter with being inefficient if the resultant color of light has been properly corrected. An accurate reproduction of daylight is the sole basis on which filters can be rated as efficient or not. The re-

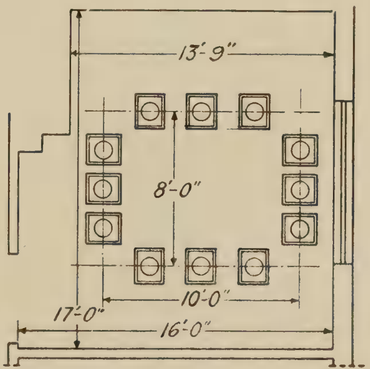


Fig. 6. Electric Daylight, Boston Lying-In Hospital.

Twelve Macbeth daylight ceiling lamps (Fig. 1) with 1000-watt clear glass bulbs and overcast-sky equivalent filters are here arranged in a rectangle on 8 ft. by 10 ft. centers.

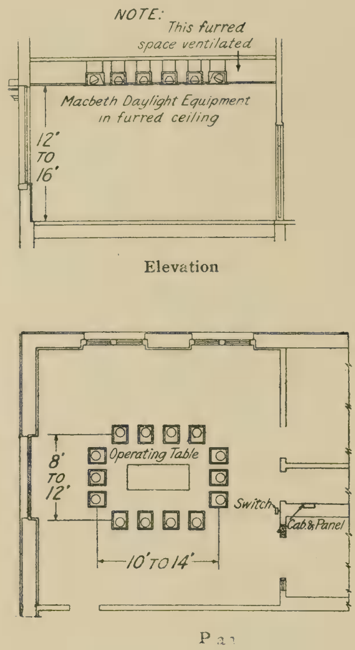


Fig. 7.—Plan and Elevation.

A suggested typical arrangement of daylight ceiling lamps. The number of lamps and size of rectangle depending upon the size of the room, the height of the ceiling and the intensity of light desired.

Fig. 8.—Operating Room Emergency Lamp as installed in Boston Lying-In Hospital.

Electric hand lamp with ample cord, connected to the storage battery circuit supplying electric clocks, annunciators, etc. In the event of a breakdown of the regular electric service, Light is here immediately available at the turn of the socket key. This is, without doubt, the most reliable always ready for use adequate light distributing combination yet developed for operating room emergency lighting.

Extra 50-watt, 32-volt bulb also stored in metal, glass door cabinet conveniently located on side wall. Cabinet 22 in. high, 12 in. wide and 4 in. deep.

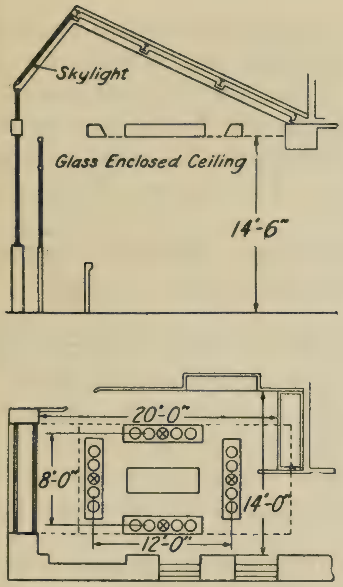


FIG. 9.—Plan and Elevation.
An operating room where daylight ceiling lamps are to be installed in an all glass ceiling below a skylight which it was desired to retain. The X-in-circle symbols indicate another circuit of ordinary artificial light from the same lamp structure as the electric daylight. This light is provided for clean up purposes and for general illumination when the room is not in use for operations.

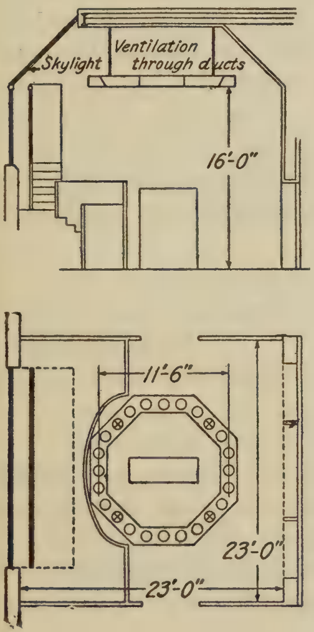


Fig. 10.—Plan and Elevation.
An amphitheater suggestion where in a comparatively small room with a 20-foot ceiling height it is planned to supply an octagonal fixture with lamps on practically 12-ft. centers, the light to be directed towards the operating table from eight sides and from 20 individual sources. Ample light from this equipment is also distributed throughout the room for its adequate general illumination. Four lamps in the same fixture on a separate circuit provide general illumination of ordinary artificial light quality. This circuit is to be electrically controlled in such a manner however, that it cannot be used along with the daylighting equipment.

sultant ratio of effective to total flux is most largely up to the distribution of luminous flux from the light source—its proportion of visible short vs. long wave lengths. And on that point the tungsten lamps we all admit as having a high efficiency are only relatively high as compared for instance to the carbon filament lamps, as in their conversion of energy into luminous flux they are still more than 90 per cent inefficient.

What about glass breakage—suppose a filter should break? That is possible but not probable. The glass is a laboratory product, is thoroughly annealed, and each filter is cut into quadrants, which are asbestos packed on the edges, supported with metal straps and bound together with a heavy channel band. In our several years' experience with thousands of these filters in use in all kinds of places we have not known of a single piece of glass, falling from a lamp. In a very small percentage of cases a filter may crack but we have never had a crack which released a piece of glass in this size filter.

About heat, with twelve to twenty kilowatts per room, twenty to forty watts per square foot, the heat generated must be considerable? It is. It is so uniformly distributed, however, and the lamp housing designed as it is to pass considerable quantities of air removes by convection what might be described as the excess heat, with the final result of a most uniformily ventilated room, with comparatively slow moving air of relatively large volume and an increased temperature due to the lamps of three to five degrees Fahrenheit and that without any forced draught or fan exhaust—simply provision above the ceiling for the escape of the heated air.

DISCUSSION

W. J. Weglener: Mr. Macbeth's talk has been enlightening literally as well as figureatively speaking and the information he has given us is particularly valuable, as it is based upon a life long study of this subject.

The Kny-Scheerer Constant Operating Room Light, is a practical light produced after many years of experience in operating rooms with surgeons. It not only meets but exceeds actua requirements. The function of the operating room light is to produce a constant, clear and concentrated light on the field of operal tion, and one that will show the true pathological colors of the

tissues. Briefly described, the Kny-Scheerer Light is a 24″ parabolic reflector with six 75-watt blue daylight lamps, mounted about seven (7) feet from the floor.

In an operation there exists the possible need of moving the patient from one position to another. In the case of most concentrated lights, the area of intense illumination is so limited as to make it difficult to move the patient without interferring with the density of illumination on the field of operation. To overcome this, our Operating Room Light has been designed so that the light is sufficiently defused to permit the moving of the patient on the table without in any way interferring with the density of illumination.

Of greatest importance to the surgeons and hospital authorities, to say nothing of the patient is the auxilliary gas lighting attachment. At first consideration this seems of minor importance, but let us go into it further, and let me tell you of an actual fact, the hospitals in Roanoke, Virginia, rely entirely on electric power as a means of illuminating their operating rooms. Recently, the power was shut off for a considerable period, and but one hospital was able to continue operating without any delay whatever. This was because they had installed our light, and when the electricity was cut off, it required but the fraction of a second for the nurse to reach up and turn on the gas light and full illumination was resumed.

In instances such as this, not only is the surgeon's reputation, as well as the reputation of the hospital injured, but of far greater importance is the fact that the patient's life may be lost through even a minutes delay in the operation.

The fact that this has happened once, simply proves that it may happen again, and our light is but a form of insurance against tragedy.

In the construction of this light, we have been able to eliminate the disagreeable feature of intense heat. The temperature existing in the operating room is 90° F. Most lights give out so great aquantity of heat, as to make the temperature so high, that it retards the action of the surgeon. Our light is well ventilated, and it has been proven that a surgeon could work continuously for over two hours directly under this light. So far as actual construction of the light is concerned, the dome outside is constructed of brass and

copper with baked white enamel finish. This means that it can be easily washed and kept perfectly clean. The bottom is of wired plate glass, which eliminates the possibility of broken glass falling on the field of operation.

Charles Crane: This question of lighting operating rooms is a very vital question. We have indeed learned a great deal from this demonstration today.

The Kny-Scheerer lamp, with its instantaneous gas connection making it possible to get the same candle power in case of an emergency from the breaking down of your own plant or the current contracted for, is a wonderful thing.

The other lighting system demonstrated is also quite a wonderful improvement on account of the perfect daylight and the reproduction of the human flesh that is given to the human flesh present here today.

I think that both of these equipments should be sent to the American Hospital Association so that they may have the necessary data to furnish Hospital Supts. and others who are vitally interested in the lighting of operating rooms and accident rooms.

Both of these gentlemen should see that their firms give this data to the Liberty Bureau of the American Hospital Association.

S. S. Frank: I have nothing particular to say other than on the subject of emergency lighting for operating rooms, just brought up by Mr. W. J. Weglener. In a hospital now in course of construction we have taken care of this in a very satisfactory way, but unfortunately it is not possible in all hospitals. There will be two sources of current supply—the New York Edison d.c. street mains for elevators and other motors; the United Electric Light & Power Company a.c. street mains for x-ray work and general illumination. Each of seven operating rooms has a circuit from each of the sources, controlled by an automatic switch that instantaneously throws in the second circuit on failure of the normal one.

At present we are contemplating installing the Artificial Daylighting system. It is quite expensive, but reports from two hospitals where it has been in use are so favorable that we have about come to the conclusion that we can not afford to omit it.

G. B. Nichols: The subject under consideration deals with two questions. There are two types of hospitals, two types of operat-

ing-rooms. In some of the hospitals, take our state hospitals for insane, with which I am familiar, there might not be more than one operation a day performed in the operating-room, and perhaps not as many as that. For that type of operating-room, it strikes me it would be rather impractical to go into Mr. Macbeth's system. In the private hospital, where a physician has his own private operating-room, he probably would go into the simpler system. But in a hospital where they were carrying on continuous operations that would require continuous service of the room, the hospital could afford the more elaborate system, and probably would, with more refinements.

A. L. Powell: My experience in dealing with surgeons and hospital superintendents has indicated that the cost of operating the lighting is practically negligible. Not only are the conditions of use very critical but a relatively high rental per hour for the room is obtained. The money which is expended for electric power is indeed a very minor item and the hospital can well afford to put in the best system that is available. A special storage battery has been used in a number of cases as an auxilliary source of power. This needs very careful supervision, otherwise the house electrician is very likely to neglect it, if it has not been called upon for a period of several months and the very time when one wishes to use the battery it may be out of commission. A much better scheme is to have the auxiliary lighting connected to the line serving bells, clocks and indicators, which system being in constant use, will be properly maintained.

W. T. Blackwell: I remember some years ago when I was connected with the City Government in New York City that we found the lighting in hospitals antiquated and no provisions made for duplicate illumination. We hit upon an expedient of using duplicate sources of illumination,—that is both gas and electricity. While it did not prove altogether satisfactory, yet it was the only means that we had of solving the problem.

One of the difficulties experienced in lamp illumination was the heat affected the silvering on the mirrored reflectors used on hospital units. Another difficulty was keeping the gas mantle lights in proper working order. Almost invariably upon inspection of the gas mantel lighting it was found that the equipment had been neglected and was not in working order.

It would seem to me that the plan of using electricity solely with separate sources of supply is a much more dependable plan. It does away entirely with the difficult maintenance of the gas system.

C. C. Colby, Jr.: It appears to me that in a good many cases there would be cause to perform an operation without a general anesthetic, that is, cases in which the patient would be conscious. I wonder if Mr. Macbeth has any installations in mind which have been made with a view to eliminating the glare in the patient's eyes, which might be a source of annoyance.

Norman Macbeth: Mr. Powell raised the point with reference to storage batteries. Undoubtedly, the storage battery makes an excellent emergency lighting system but all emergency lighting systems should be used every day, the battery should have clock or annunciator duty to insure its regular maintenance.

I recall a recent breakdown of hospital operating room lighting service from an electric plant that had not been off before in twenty years. Can you imagine an emergency service, maintained solely as such for twenty-one years which would be one hundred per cent available unless the service was also used for some every day purpose?

Many of the members recall that I had some gas experience. It was found in department stores and other places where gas mantle lamps were used for emergency, that they were not there with the desirable light output when the emergency arose. A mantle is highly hydroscopic; it will take up a great deal of moisture and dust. The gas should be used frequently. You can use your electric with it, or use your electric for an emergency, but you can't have an emergency gas lamp unless it is practically in constant use. That was found to be the case in a city I recall where they had a good many electrical breakdowns and as a consequence all the department stores largely dublicated their installations. But they weren't used as duplicate installations; they were used as supplement installations. Gas and electric lamps were regularly in use throughout each floor.

In talking to a surgeon from Winnipeg a short time ago he told me that at one time, just in the midst of an operation a thunderstorm struck them, and since their plant was of the hydro-electric type, the lines went down. It happened that somebody had a

flashlight; you can get remarkably good service from such a small lamp over a small area. The flashlight saved the situation for him.

I recall a discussion on hospital lighting in England a short time ago, and their conclusion was also that a good storage battery outfit with two or three lamps made the best emergency, provided they were used frequently.

Mr. Nichols speaks about an ordinary operating-room where they have an operation a day. I have been informed that there are days when they cannot operate, as natural daylight is not sufficient at any hour of the day.

While this system here may seem exceedingly elaborate from the standpoint of lighting, it isn't unduly expensive when compared with other hospital equipment. I was talking to Dr. Winford Smith director of John Hopkins. He was very proud of his new sterilizing outfit. That outfit cost $100 more than the lighting equipment. When our demonstration was made down there, one of the surgeons asked, "What have we got in the old operating-room?" I said, "You have a 300-watt lamp in the metal reflector. We have 16,000 watts here. He said, "We can't go from 300 to 16,000." But I explained we have to consider such a question relatively. If you want this kind of lighting you can have it. Let us consider its relative cost. Don't consider the value of the patient's life, or how important that patient may be, but merely the standby charges in the operating-room, even the steam heating element, don't neglect the minor cost of the cotton gauze that they sop up and throw away (they don't waste it any more, they reclaim it), and the cost of reclaiming.

After you have this total, I am not inclined to believe that this system will be considered relatively expensive with a cost of approximately 50 cents an hour to run. What is 50 cents an hour if you can practically lift the roof off your operating room and have day-light from all angles and at a desirable intensity 24 hours of the day?

That brings up another point. I receive inquiries, "Send us particulars about your lamp," To which we reply, "We haven't got a lamp. Send us particulars of your operating-room." In other words, it is a lighting system that has to be fitted into the place in which it is to be used.

Chairman Powell: You don't answer Mr. Colby's question about glare.

Norman Macbeth: That question hasn't been raised in any of our installations. We can take care of any reasonable demand as far as glare is concerned for an observer or worker in any position in the room, of course, with a patient not under an anesthetic, lying flat on his back looking up at the ceiling, it is a different matter, but so far as any one else in the room is concerned, all the other out-off angles in this equipment are below 60 degrees from the vertical; some of the light is out-off at 45 degrees, so it is only by looking directly up at the lamps you can see the bright filaments which of course, are tremendously toned down, when viewed through the filters.

I saw an article, a short time ago, about some operation they performed with a local anesthetic, and they clamped a radio receiving set on the patient's head so he could get a little diversion. Perhaps he can get a little side diversion also from a view of these lamps.

ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

THE COLORIMETRY AND PHOTOMETRY OF DAYLIGHT AND INCANDESCENT ILLUMINANTS BY THE METHOD OF ROTARY DISPERSION*

BY IRWIN C. PRIEST

SYNOPSIS: Further studies, both theoretical and experimental have been made on toe methods of photometry and colorimetry previously proposed by the author. (Phy. Rev. (2) 9, p. 341; 1917. Phy. Rev. (2) 10, p. 208; 1917. J. Op. Soc. Am. 5, p. 178; 1921. J. Op. Soc. Am. 6, p. 27; 1922. B.S. Sci. Pap. 443; 1922).

In the light of this work, the method is now proposed as a complete and satisfactory solution of the practical problem of the visual photometry and colorimetry of the illuminants (including the important phases of daylight) whose spectral distribution approximates the Planckian formula closely enough to give a color match. This solution is based upon the principle of the additivity of homogenous luminosities and the assumption of a standard visibility function.

The method falls in the general class of substitution "equality of brightness" methods. All brightness matches are made at a color match. This color match is obtained by modifying the color of a constant comparison source by allowing its light to pass through a train of nicol prisms and quartz plates which form, in effect, a blue or yellow filter of continuously adjustable spectral transmission.

Tables and graphs have been prepared by which color temperature and candlepower or brightness may be readily obtained from the instrument readings on the basis of any visibility which it is desired to assume as standard.

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(Mr. Priest exhibited a model of the "Rotatory Dispersion Colorimetric Photometer" as constructed by the Bureau of Standards for use in the colorimetry and photometry of daylight and incandescent illuminants.)

This instrument represents the chief tangible result of the development of an idea with which I have been working more or less intermittently for more than eight years. During that period

*Stenographic report of a paper delivered by invitation before the Seventeenth Annual Convention of the Illuminating Engineering Society at Lake George, N. Y. Sept. 26, 1923, as revised and amended by the speaker. Published by permission of the Director of the Bureau of Standards, U. S. Department of Commerce, and the Director of the Munsell Research Laboratory. The instrument described was developed in part while the author was an employee of the Bureau of Standards and in part while a Research Associate of the Munsell Color Co., stationed at the Bureau of Standards.

I have published a number of somewhat fragmentary and inadequate papers on various phases of this subject, but, up to date, there has been no adequate publication and no unified treatment of the subject. However, a paper which I hope will be an adequate presentation of the whole subject will appear in the December number of the Journal of the Optical Society.

My chief purpose in accepting the invitation of your Papers Committee to speak at this meeting was to present the subject personally in a more concrete manner by exhibiting this instrument and demonstrating it to you. With this point of view, I do not intend to weary you with a detailed exposition of the theory of the instrument which I think you can follow much more to your own satisfaction and convenience in the printed paper which will appear later. If you do this, you will find some rather formidable mathematical formulas; but I assure you they are perfectly harmless and they do not militate in any degree against the usefulness or practical value of the method. In the paper they serve the purpose of brevity of expression—and I believe that it is commonly understood that such decorations add to the dignity of a scientific paper—but their detailed consideration here might have a depressing effect on what might otherwise be an enjoyable occasion.

To get to the meat of this matter, this instrument serves two purposes which are somewhat distinct but at the same time are very closely related.

The first purpose is the color grading of all the ordinary phases of daylight and all the incandescent illuminants on a simple, intelligible scale color, that is on the scale of color temperature as first developed largely by Hyde, his colleagues, and others, and notably extended by the use of this instrument. The extension consists of extending the experimental range of the method from about 3,200 degrees absolute, where Hyde's work left it, up to the quality of the color of daylight and the blue sky, that is, up to color temperatures in the neighborhood of 20,000 or 24,000 degrees absolute.

The second purpose of the instrument is to afford a means of comparing the relative intensities of illuminants in spite of their difference of quality, and in doing this it covers the whole field of the various phases of daylight, and all the incandescent illumin-

ants, down to the yellow Hefner lamp. That is, it circumvents the difficulties of heterochromatic photometry. It does this, of course, on the basis of an assumed standard for the visibility function which Dr. Gibson was discussing a few minutes ago.

I believe I can present this subject most clearly by describing first the instrument and its use, getting right down to brass and glass in its application, rather than by following the usual procedure of such a presentation and elaborating on the theory first and then showing its incorporation into the instrument.

* * * * * * * * * * * *

At this point the speaker described the instrument and its use, pointing out its principal parts both on the instrument itself and on diagrams (by lantern slides) showing its construction. He also exhibited, by a lantern slide diagram, representative standard data on the color temperature of various phases of daylight and various incandescent illuminants. Since this portion of the discourse can not be understood without reference to the diagrams, reference must be made to a paper which will appear under the same title in the Journal of the Optical Society of America, December, 1923.)

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This method and instrument provide means for the specification of color quality and the measurement of relative intensity for all incandescent illuminants and the important phases of daylight, including, on one extreme, the Hefner lamp, and, on the other, the blue sky. The practical solution of the problem of the photometry of illuminants of different quality here proposed is given explicity in the most simple and fundamental terms possible in the nature of the problem. The method is free of non-reproducible terms and temporary expedients in specification. At the same time it appears to be convenient and well adapted to ordinary routine work in the laboratory or in the field. This method and instrument are therefore recommended to the consideration of the Illuminating Engineering Society as a fundamental and convenient solution of the problems of the colorimetry and photometry of incandescent sources and daylight.

There is obviously a great deal of detail which I can not discuss within the time now avaliable. (Among other items is the

use of the "spectral centroid of light" as a color index in some respects preferable to "color temperature".) I have planned to set up this instrument in the lobby upstairs with some lamps which I have brought along. I will exhibit it in operation and let those who may be interested stop there this afternoon and look into it. I have here the complete manuscript of the paper including the figures, and will have it upstairs with the instrument. Those who are interested may come and talk with me about it; those who are not may play golf. (The instrument was exhibited in operation in the hotel lobby during the afternoon)

DISCUSSION

M. Luckiesh: As one interested in color measurement for a great many years I want to take this opportunity of expressing my appreciation to Dr. Priest for the culmination of a really fine job.

I confess that at times I was rather doubtful as to the outcome of an instrument using nicol prisms, not on account of Dr. Priest's ability at all but on account of the fact that I have abhorred nicol prisms in certain work.

I am sorry Dr. Priest did not have time to go into the details of this. To me, it is most fascinating because it puts color measurement on a mathematical basis. I have often used mathematical relations and spectrophotometric curves for getting many data results without having to make measurements with an instrument.

Mr. Priest's instrument, being based on mathematical curves and being developed to this high state, I think is going to provide a means for a good deal of valuable data. I hope that he can extend it so we can get over into the measurement of hue and even over into that great field beyond black body radiation. But even for that alone, it seems to me we have something now that we have never had before—an instrument from which we can build various scales.

A. H. Taylor: I would like to ask a few questions about this. One is whether there are any of the individual parts of this instrument which would require an experimental calibration; or, in other words, whether the curves which Mr. Priest has worked out apply alike to all instruments made up as nearly as possible identical with this one; second, whether it is possible with this instrument to match colors of sources which do not have a black

body distribution of energy—for example, the gas mantle, or in a more extreme case, colored glass which doesn't have a systematic or uniform spectral distribution, or transmission; and third, as to the degree of accuracy which you can obtain with the instrument; that is, I don't mean so much in measurements of candlepower (although I would like to know that) but color temperature; for example, just how accurately you can measure color temperature.

MAX POSER: I would like to ask Mr. Priest whether he found any method of standardizing the effectivity of the nicol prisms when made in quantities.

NORMAN MACBETH: It may be of passing interest in this connection to state that we have developed an instrument for the measurement of daylight in units of color and intensity. This instrument enables us to measure also any color change from the ordinary Mazda lamp or even from a carbon filament lamp through the color changes to the extreme of blue sky daylight. The color temperature equivalents may also be noted to the point where we reach the maximum of direct sunlight at noon.

We have used a certain blue glass that we call daylight glass. Two wedges were made, these are about 15 centimeters long, 3 millimeters thick on one end and 1 millimeter at the other end. These wedges intercept a beam of light from a lamp house on a photometer track. Varying the distance between the lamp and Lummer-Brodhun cube permits an intensity match. The outside field of the comparison prism may be turned towards a white glass test plate or towards the sky or even a particular cloud in the sky. The color match depends upon the density of these daylight glass wedges interposed in the light path. Then as this particular blue glass is a definite mixture of three distinct colors of glass; a signal green, a full amethyst and a very pale blue; three additional sets of wedges of these glasses may also be used, so if at any time we should find a daylight color that varied from that which could ordinarily be matched with the daylight glass wedges we can add any or all of these colors, any combination of which can be reproduced in a single glass to be used as a filter with a Mazda lamp as the source, for an exact reproduction of any color of light matched in this daylight colorimeter.

We also have another daylight glass, the composition of which was worked out by Ives and Brady. This is a glass

which Mr. Priest tells us perfectly possesses the property of raising the apparent color temperature of one black body to that of another, consequently with various densities of this glass and a Mazda filament source any black body color can be matched. The Gage-Corning glass, of which the first mentioned wedges were made, is not a "sunlight" glass. That is to say, it will not result in an exact sunlight or black body radiation color match. It is my understanding that natural daylight from which direct sunlight is absent is not an exact visual match for any black body temperature color and the Gage glass possesses this daylight color characteristic. This colorimeter is not on the market nor do I believe it is likely to be as it was brought out in the usual course of our daylighting development to maintain a check on our own work. This instrument of Mr. Priest's probably permits a great many determinations that we cannot make. At the same time, I believe that we can make many measurements of considerable value in our particular work that Mr. Priest cannot make so exactly, but as our work is highly specialized I do not believe that this in any manner detracts from Mr. Priest's achievement.

Mr. I. G. Priest: Beginning with Mr. Macbeth's question, I should say that probably the chief utility of this instrument for his purpose would be the calibration of his wedges in terms of color temperature. Probably a much cheaper and simpler instrument can be made for a great deal of field work, although personally I should not prefer it. I would prefer to take this instrument into the field.

Coming to Mr. Taylor's and Dr. Poser's remarks, I should have answered Mr. Taylor's first question before it was asked. I intended to make it a part of my presentation, but did not do so because of the limited time. The instrument is completely reproducible from specifications. It is not dependent upon an emperic calibration. However, the computation from given constants of the instrument—which any one might be excused for questioning—has been checked experimentally so that over considerable ranges we have both the computed calibration curve, (*i.e.* the theoretical calibration) and the emperic calibration curve. Some data on the comparison of the theoretical and empiric calibrations were given in a paper which I presented at the Optical Society nearly two years ago and have been published in Bureau of

Standards Scientific Paper, Number 443. In that paper it is shown that color temperatures measured by means of the theoretical calibration of the instrument checked with color temperatures obtained by other means. For example, values reported independently by Dr. Forsythe of the Nela Research Laboratory were checked with surprising accuracy.

In regard to Mr. Taylor's question about measurement of the color filters of course it should be stated there are several cases in which you can make a color match with this instrument. In the first place, you have identity or what may for practical purposes be called identity of spectral distribution between the test lamp and the distribution which you manufacture by means of the instrument. That, of course, gives a perfect color match. Then you have the case where you make a color match with the test lamp, the test lamp having a different spectral distribution than that produced to color match it. A good example, perhaps the best example of that case is the case of the artificial daylight units such as have been proposed by Ives, Luckiesh and others. There we can measure the apparent color temperature of the artificial daylight unit with this instrument, but the daylight unit does not have the same spectral distribution because the glass has little kinks in its spectral transmission curve. The Ives-Brady glass, with the sources which are used with it, gives a perfect color matching. The conditions of the two cases are somewhat different.

There is a still further case where we get only an approximate color match, where it isn't possible with this instrument to match the source because it has not the spectral distribution characteristic of a black body. Such a case is the Moore carbon dioxide lamp. If we make observations on a Moore lamp (as we have done) our experimental data represent the temperature at which the color of a black body would most closely approximate to the Moore lamp, and the color difference then existent in the field is not much more than the least perceptible difference. But the Moore lamp is not a perfect color match to a black body and its spectral distribution of course as many of you know is widely different from a black body.

With regard to photometric accuracy, I published a great many years ago some preliminary photometric results which

showed I think very good agreement, within a per cent or so, with values obtained otherwise.

I had some more slides to present dealing with the selection of standard visibility data. I will sum that all up without presenting the slides by saying that of course we assume a standard visibility function as a fundamental standard in this method. It makes absolutely no difference, however, for the determination of the relative intensities of illuminants, whether you choose the I. E. S. curve, the curve which I used, or the curve by Gibson and Tyndall, or any other reasonable average; the results will be the same within the ultimate possible precision of photometric work.

SOCIETY AFFAIRS

SECTION ACTIVITIES

NEW YORK Meeting—October 18, 1923

At the first meeting of the New York Section held on October 18, a paper, "Lighting and Signal System of the Leviathan", was presented by Mr. W. M. Zippler, Electrical Engineer, Gibbs Brothers, Inc., New York. Prior to the meeting, the Dinner Committee successfully arranged a table d'hote dinner at Shanley's Restaurant, 117 West Forty-Second Street. After the meeting the members and guests visited the S. S. Leviathan where an inspection trip was made. The time allotted for the members and guests of the I. E. S. for visiting the Leviathan was from 8:00 to 10:00 P. M. It was estimated that about 400 people visited the Leviathan, and there were 150 members and guests at the dinner.

PHILADELPHIA Meeting—October 22, 1923

The Philadelphia Section met at the Engineers' Club on October 22 to discuss a number of papers presented as follows:

"The relationship of the Scientist to Illuminating Engineering," By Laurence A. Hawkins, Research Laboratory of General Electric Co.; "The relation of Illuminating Engineering to the Central Station," By C. J. Russell, Vice-President, Philadelphia Electric Co.; "Proper lighting as an aid in the prevention of Accidents," By R. E. Simpson, Engineer, Travelers Insurance Co.; "Illuminating Engineering as an aid to the Architect," By Emile G. Perrot, Architect and Engineer, Philadelphia; "Artificial Light in the Home," By M. Luckiesh, Director, Laboratory of Applied Science, National Electric Lamp Works of G. E. Co.; "Illumination in Industry," By Jos. G. Crosby, Vice-President & General Manager, Whalen Crosby Electric Company, Philadelphia; "The Effect of Modern Illuminants on the Eye" By Dr. George S. Crampton, Opthalmologist, Philadelphia.

Preceding the meeting, members and guests to the number of twenty-five were served with dinner at the Engineer's Club. This being the opening meeting of the year, the Chairman opened the meeting with a brief address to the members and guests, stating the scope and purpose of the Society, the object of the Philadelphia Section and the aim of the Officers and Papers Committee during the coming Section Year.

Mr. G. B. Regar, Chairman of the I. E. S. Committee on Membership spoke of the increase in membership of the Society, calling particular attention to the results of last year. He urged that the Philadelphia Section be particularly active in this line.

After the presentation of the Papers for the evening an interesting discussion followed, which was participated in by Mr. Jos. D. Israel, Dr. Geo. A. Hoadley, Mr. Frank Lewis, of Baltimore, and Mr. M. E. Arnold.

CHICAGO Meeting—October 31, 1923

The section met at the Benjamin Electric Mfg. Co. Chicago Office at 12:30 P. M. and drove via automobile to the Copper Kettle at Oak Park, Illinois where lunch was served and then proceeded to the Benjamin Electric Mfg. Co. Factory, DesPlaines, Illinois.

At 3:00 P. M. the members and guests made an inspection trip through the factory accompanied by guides who explained the various processes in the manufacture of porcelain steel lighting equipment.

At 5 o'clock the various groups returned to the meeting place, Messrs. A. E. Clark and W. E. Quivey, of the Benjamin Electric Mfg. Company, gave a short talk on illumination as applied to their products. Mr. H. S. Thayer of the Atlas Electric Devices Company gave a short talk on the Violet Arc Fading Machine. Mr. W. J. Guntz of the Paul E. Johnson Co. gave a short talk followed by a discussion of the quartz tube mercury vapor unit used for light therapy.

NEW ENGLAND Meeting—October 26, 1923

The subject for discussion at the New England Section meeting on October 26 was a series of solutions of a lighting problem. Messrs. R. B. Brown, James A. Toohey, L. S. Purdy and W. D. McCabe presented solutions which were discussed by Messrs. R. B. Burnham, Philip Drinker and A. H. Hirons.

The meeting was held at the Engineers' Club and there was an attendance of fifty members and guests. Resolutions were adopted expressing regret of the death of Dr. Charles P. Steinmetz, Past-President, I. E. S.

MICHIGAN Meeting—November 2, 1923

The Michigan Chapter opened the *Year of Cooperation* with a joint meeting of the Industrial Engineers Society of Detroit and the Electrical Extension Bureau of Detroit. In the Detroit Edison Company's Auditorium, Mr. Ward Harrison Illuminating Engineer, National Lamp Works of G. E. Co., Cleveland, Ohio, gave a lecture and demonstration of "Control of Light".

There were 353 members and guests present at this lecture. Architects, factory and store executives safety engineers, factory maintenance engineers, and representatives of all branches of the electrical industry were present. This attendance was attained through extensive advertising, letters to a selected mailing list, 500 printed posters, and splendid cooperation from the Detroit Safety Council, Detroit Retail Merchants Association electrical jobbers, electrical Extension Bureau and the Detroit Society of Industrial Engineers.

The Chapter is planning a series of four or five more joint meetings for the *Year of Cooperation*, some of general interest and some of special interest to various groups which will be open to the public.

NORTHERN NEW JERSEY Meeting—October 31, 1923

A joint meeting with the "Ourselves Club" was held at Hackensack, N. J., October 31, 1923. The "Ourselves Club" is an organization of electrical con-

tractors and dealers and other people actively engaged in the electrical industry. Mr. Samuel G. Hibben gave a very interesting talk on "Facts on Lighting and Use of Light".

Using some ingenious portable apparatus, Mr. Hibben accompanied his talk by giving very interesting demonstrations of light control, and showed what astonishing changes can be obtained from a single display by using light of various colors. Using a "shadow box" which permitted light to be thrown from different directions upon small statues and plaster masks, the effects of shadows on lighted displays were shown. Both the lecture and the demonstrations were not only interesting but of practical value to those present, as many of the lighting effects demonstrated can with advantage be applied in lighting of show windows or other displays, and may be directly applied by the electrical contractors in their work along these lines.

An audience of sixty-five was present including Mr. Clarence L. Law, President of the Illuminating Engineering Society. Mr. Law spoke briefly of the satisfaction which he felt on seeing the meeting so well attended and congratulated both the officials of the "Ourselves Club" and of the Northern New Jersey Chapter on the excellent work they were doing in furthering better lighting practice and the idea of cooperation between electrical contractors and dealers and the illuminating engineers.

TORONTO Meeting—October 15, 1923

The first meeting of the Toronto Chapter was held at the School of Science, University of Toronto on October 15, Messrs. George G. Cousins and W. H. Woods presented a resumé of the principal papers discussed at the Lake George Convention of the I. E. S.

At this meeting committees were appointed to draw up a tentative "Code of Industrial Illumination" for consideration of the Provincial Government at the request of the Canadian Electrical Association, and to consider "Automobile Number Plate Illumination" and report to the Provincial Government.

PITTSBURGH Meeting—October 25, 1923

The organization meeting of the Pittsburgh Chapter was held on October 25, in attendance there were forty members and guests. The following officers were elected: Chairman, Franklin W. Loomis; Secretary-Treasurer, Sanford C. Lovett; Executive Committee, L. J. Kiefer, G. W. Ward, J. P. Warner; Committee Chairmen: Papers, E. Y. Davidson, Jr., Membership, Douglas Wood; Attendance and Publicity, J. J. Husson; Entertainment, J. H. Van Aernam.

COUNCIL NOTES

ITEMS OF INTEREST

At the meeting of the Council, November 8, 1923 the following were elected to membership:

Eleven Associate Members

BYRNE, THOMAS W., Electrical Engineer, 710 Little Bldg., 80 Boylston St., Boston.

DOLBEARE, WALTER IRVING, Commercial Lighting Salesman, Blackstone Valley Gas & Electric Co. 231 Main St., Pawtucket, R. I.

FLANAGAN, E. C., Salesman, Illuminating Glassware, The Phoenix Glass Co. P. O. Box 757, Pittsburgh, Pa.

HUNTER, T. A., Manager, Lighting Dept. Pacific States Electric Co., 236 S. Los Angeles St., Los Angeles, Calif.

KARAPETOFF, VLADIMIR, Professor of Electrical Engineering, Cornell University, 607 East State St., Ithaca, N. Y.

KING, FLOYD E., Salesman, Wheeler Reflector Co., 156 Pearl St., Boston, Mass.

LOVETT, SANFORD C., Edison Lamp Manager General Electric Co., 1318 Oliver Bldg., Pittsburgh, Pa.

PIERSOL, ROBERT JAMES, Illumination Research Engineer, Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa.

SHRYOCK, EDWIN W., Illuminating Specialist, West Penn Power Co., 14 Wood St., Pittsburgh, Pa.

VAN AERNAM, J. H., Electrical Jobber, Iron City Electric Co., 436 Seventh Avenue, Pittsburgh, Pa.

WESTERVELT, A. E., Manager, Lighting Inspection Bureau, The New York Edison Co. 130 East 15th St., New York, N. Y.

OTHER CHANGES IN MEMBERSHIP

One Transfer to Member

MAYO, HERBERT J., Sales Engineer, Benjamin Electric Mfg. Co., 582 Howard St., San Francisco, Calif.

One Member Reinstated

OWENS, H. THURSTON, 51 East 42nd St., New York, N. Y.

The General Secretary reported the death, on October 27, 1923 of one member, L. E. Voyer; Illuminating Engineer, San Francisco Office, General Electric Co., San Francisco, Cal., and four associate members, in the recent Japanese earthquake, as follows: Tetsuya Fujii; Engineer in charge of Laboratory, Tokyo Electric Co., Kawasaki-machi, Kanagawa Ken, Tokyo, Japan. Kenjiro Kato; Chief of Engineering Section, Tokyo Electric Co., Kawasaki-machi, Kanagawa Ken, Japan. K. Khikata; Tokyo Electric Co., Kawaski, Kanagawa-Ken, Japan. Hannosuke Murota; Electrical Engineer, Tokyo Electric Co., Kawasaki-Kanagawa, Ken, Japan.

Upon the recommendation of the Council Executive Committee, Mr. Norman D. Macdonald, was appointed General Secretary to fill the unexpired term of Mr. Samuel G. Hibben. The resignation of Mr. Hibben as General Secretary was presented to the Council on October 11, 1923 to take effect November 8, 1923.

CONFIRMATION OF APPOINTMENTS

As members of the Committee on Motor Vehicle Lighting—F. C. Caldwell, E. C. Crittenden, A. W. Devine, C. E. Godley, C. A. B. Halvorson, Jr., John A. Hoeveler, W. A. McKay, A. L. McMurtry, H. H. Magdsick, L. C. Porter.

As members of Committee on Sky Brightness—H. H. Kimball, Chairman, E. C. Crittenden, E. H. Hobbie, James E. Ives, Bassett Jones, W. F. Little, M. Luckiesh, L. B. Marks, I. G. Priest.

As members of Committee on Membership—C. E. Addie and F. H. Murphy.

As members of Committee on Sustaining Members—W. T. Blackwell and E. J. Teberg.

As Official Representative on the U. S. National Committee of the International Commission on Illumination—G. H. Stickeny.

As Local Representative at Salt Lake City—L. B. Gawan.

At the meeting of the Executive Committee of the Council held on October 25, 1923, the petition for a charter presented by the Pittsburgh Chapter was granted.

NEWS ITEMS

Professor Vladimir Karapetoff of the School of Electrical Engineering, Cornell University, has been awarded a prize of four thousand francs by the Montefiore Foundation of the University of Liege, Belgium. The award was made for his kinematic computing devices of electrical machinery, described in the technical press during the last three years. A committee of five Belgian and five foreign members, which makes these awards, has characterized this work as an expression of a "new idea which may lead to important developments in the domain of electricity".

Mr. L. E. Voyer, assistant local sales manager of the Edison Lamp Works of the General Electric Company at San Francisco, died October 27, 1923 of double pneumonia after a five days' illness. He was well known as an illuminating engineer, especially throughout the Pacific Coast section, where he will be remembered for his notable work in connection with the headlight laws of the state motor vehicle act in California, his assistance in the Panama-Pacific Industrial Exposition and his work in advancing lighting practice in the state of California. He took an active and guiding part in the establishment of various lighting regulations there, including the Code of Lighting for industrial plants. One of his first activities was in connection with the headlights used on railway locomotives, when he secured a more logical interpretation of those laws both in California and Nevada.

Mr. Voyer was born September 10, 1887, at Junction City, Wisconsin. He entered the employ of the General Electric Company at Harrison, N. J., in 1911 as a student engineer. In 1912 he was transferred to the illuminating engineering department at Harrison and in 1913 he was transferred to the San Francisco office as a special illuminating expert. He was an alumnus of the University of Wisconsin, class of 1911. He has been constantly in communication with illuminating engineering work in the east, being active in the work of the Illuminating Engineering Society. As western representative of this organization on the Committee on Motor Vehicle Lighting he assisted in the co-ordination of regulations adopted in various states. He established the Bay Cities chapter of the Illuminating Engineering Society, being its first chairman.

The Japanese earthquake exacted a toll of lives among Illuminating Engineers. A report just received from Mr. M. Uchisaka, Tokyo Electric Company, Limited, gives the following members of the society as among those who lost their lives in that catastrophe—Tetsuya Fujii, Kenjiro Kato, Hamnosuke Murota, and Kimo Shikata. In addition, Mr. T. H. Amrine, who was a member of the Society when connected with the Edison Lamp Works of General Electric Company, at Harrison, N. J., was lost with his family.

Although several of the buildings of the Tokyo Electric Company's lamp factory at Kawasaki were razed by the earthquake, the Japanese have, with their customary energy, been rapidly reconstructing and are already manufacturing in quantity to meet the demand.

The negative of the group picture taken at the Lake George Convention last September has been sent to the General Office. Orders for the group photograph may be sent to the General Office up to December 31, 1923, the cost of the photograph will be $1.50 delivered.

ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS.

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on illumi-ting engineering and allied subjects. This index is arranged alphabetically according the names of the reference publications. The references are then given in order of date of publication. Important references not appearing herein should be called to attention of the Illuminating Engineering Society, 29 W. 39th St., New York, N. Y.

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